SWAINE

REPORT ON

CONNECTICUT RIVER BASIN BANK EROSION STUDY

(RECONNAISSANCE REPORT)

New England River Basins Commission

Technical Committee on Bank Erosion

1 JUNE 1974

R E P O R T

O N

C O N N E C T I C U T   R I V E R   B A S I N

BANK EROSION STUDY
(RECONNAISSANCE REPORT)

NEW ENGLAND RIVER BASINS COMMISSION
TECHNICAL COMMITTEE ON BANK EROSION

1 JUNE 1974

CONNECTICUT RIVER BASIN
BANK EROSION STUDY

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ACKNOWLEDGEMENTS

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ATTACHMENTS

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CONNECTICUT RIVER BASIN
BANK EROSION STUDY
(RECONNAISSANCE REPORT)

1 June 1974

1. Background

The New England River Basins Commission held a quarterly meeting on 12 December 1973. At the request of the State of New Hampshire, the Commission approved the following motion:

> "To authorize the Chairman to appoint a small ad hoc study committee of appropriate experts from various governmental units to assess river bank erosion, and other related matters, relative to the Federal Power Commission's relicensing of dams on the Connecticut River; and to report back expeditiously to the Chairman with their recommendations."

The New England River Basins Commission, by memorandum of 19 December 1973, requested that the Corps of Engineers chair a technical committee in response to the Commission resolution and to report back to the Commission. Accordingly, the Corps chaired an ad hoc committee to look into the erosion problem at the specified areas. This Interim Report is based on the studies of various members of the ad hoc committee.

2. Coordination

The Corps of Engineers held an initial Erosion Study meeting at the Corps' offices in Waltham, Massachusetts, on 31 January 1974. The following is a list of organizations that were invited to the meeting and were asked to participate in the study:

Corps of Engineers, New England Division
U. S. Department of Agriculture, Soil Conservation Service
U. S. Department of the Interior
Environmental Protection Agency
New England River Basins Commission
Federal Power Commission
State of New Hampshire
State of Vermont
New England Power Company

All of these organizations were represented at this meeting and each agreed to contribute to the study. The New England River Basins Commission was asked to use their Connecticut River Supplemental Study's public advisory structure to assist in this study. Accordingly, a member of the Science Advisory Group attended the Erosion Study meeting. The minutes of this meeting are included here as Attachment 1.

A final meeting was at the same location on 18 April 1974. The purpose of that meeting was to review and comment on the report which was in draft and to develop a final report with conclusions and recommendations. All of the participating organizations were represented at that meeting, and this report reflects opinions and views of participants. The attendance list of that final meeting is presented in Attachment 2.

This report was prepared by the Corps of Engineers. Drafts were circulated to study members for review and comment. Every effort was made to reconcile differences which arose on various matters; in some cases, differences were reconciled, and in other cases, the Corps of Engineers has, after reviewing the available data and consulting with other study members, presented what the Corps considers its best judgement on the matter.

3. Study Area

The study area consists of the reservoir banks and the river reaches between three hydroelectric projects on the Connecticut River in New Hampshire and Vermont. The three projects, Vernon, Bellows Falls and Wilder, are all owned by the New England Power Company (NEPCO). NEPCO has applied for a Federal Power Commission license renewal to continue operation at all three plants. The study area is shown on Figure 1; the reservoirs of Vernon, Bellows Falls and Wilder are shown on Plates 1, 2 and 3, respectively.

Vernon Dam is located at mile 141.9 on the Connecticut River, about 5.6 miles upstream of the Massachusetts State Line. Vernon Pool is about 27.7 miles long with its upstream limit near the New Hampshire Route 123 bridge in Walpole. Bellows Falls Dam is located at river mile 173.7 or about 4.1 miles upstream of the upper limit to the Vernon Pool. The Bellows Falls Pool inundates a 25.3 mile reach of the Connecticut River between Bellows Falls, Vermont and a point about a mile south of Windsor, Vermont. Wilder Dam, at mile 217.4 on the Connecticut River, is located about 18.4 miles upstream of the upper limit of the Bellows Falls Pool. Wilder Pool inundates about 45.5 miles of Connecticut River between Wilder, Vermont and a point 3.0 miles downstream of the Wells River.

The study involves a 121.0 mile reach of the Connecticut River between Vernon Dam and the upper limit of the Wilder Pool. The three hydroelectric projects in this reach of river impound water along a total of 98.5 miles of the river.

4. The Erosion Problem

The Soil Conservation Service (SCS) reported on erosion problems from Vernon Dam to the headwaters of Wilder Pool. The work area consists of portions of six counties -- Cheshire, Sullivan and Grafton in New Hampshire, and Windham, Windsor and Orange in Vermont. Included were the areas of non-impounded river between the Vernon and Bellows Falls Pools and the Bellows Falls and Wilder Pools. The SCS report (Appendix A) presents the erosion problems on a county-by-county basis, as the data were collected. The data vary in the amount of detail. Very little is presented for Windham County, but lengths of eroded bank were presented for Cheshire and Grafton counties. Data for Sullivan, Windsor and Orange Counties include length of streambank eroded; annual loss estimates of earth volume and acreage; bank slope, as well as soil type and description.

On examination of the SCS report and maps, it becomes evident that erosion problems are widespread throughout the study area and fairly uniform; although the Wilder Pool does seem to have a slightly higher concentration of problem areas.

The SCS report reveals that 51.0 of the 242.0 miles, or 21.1%, of river bank investigated show erosion. SCS has estimated the annual loss of bank in both cubic yards and acres for Sullivan County, New Hampshire and Windsor and Orange Counties in Vermont. These three counties lose an estimated 19.6 acres of land or 215,000 cubic yards annually. Proportioning this to the length of shoreline in reservoirs of the three dams, it appears that approximately 32 acres or 350,000 cubic yards are being lost annually. This figure of land lost to erosion represents the gross values of area and volume actually removed from the banks. No effort was made to evaluate the amount of shoaling which is taking place at the same time. It is quite possible that the amount of new land being formed by deposition will equal the amount being lost.

The New England Power Company prepared a report (Appendix B) and furnished other information valuable to this investigation. The NEPCO information furnished, relates principally to the Wilder project and allows for a more detailed investigation than could be undertaken for the other two projects.[1] All three hydro projects are very similar in physical layout and operation, and the problems and causes at Wilder seem to be typical of what is happening at Bellows Falls and Vernon.

[1] Considering the resources available to do this study.

The wealth of information gathered by NEPCO, owner of all three projects on Wilder, makes Wilder the most practical choice for this detailed examination. NEPCO is now in litigation on the relicensing of the three plants, and this litigation makes it inadvisable for them to furnish much of the information in their files as exhibits. The following, however, draws heavily on what NEPCO has provided.[1]

Wilder Dam is located on the Connecticut River, about two miles downstream of Hanover, New Hampshire. The pool, about 45-1/2 miles long, has its headwaters at Howard Island, about three miles downstream of Woodsville, New Hampshire. Plate 1 shows Wilder Dam and Reservoir. The 4.85 square miles of surface area would present excellent recreational opportunities except that water quality in the river is rather low. Despite this, the pond is active with boats in the summer and the shoreline is being developed. As existing water quality standards are met in the future, development pressures at Wilder will accelerate.

NEPCO, who owns the dam and either owns or has flowage rights on the shoreline of the reservoir, has encouraged recreational use of the pond with the construction of several boat launching ramps. They have not, however, encouraged development of the shoreline. Since NEPCO holds only flowage rights on most of the shoreline, they cannot control development along the shoreline. The Company seems concerned at the development which has been going on because much of it appears to be flood prone or erosion prone.

NEPCO has kept records of erosion in the Wilder Pond since Wilder Dam was reconstructed in 1950. The records since 1963 are meticulous; each area of erosion is recorded and photographed in each of four inspection trips in 1963, 1969, 1972 and 1973. The written records and photographs are indexed to a 1" = 1000' scale map of the 45-1/2 mile river reach between the dam and the Wells River. Areas that have been subjected to erosion are plotted to scale on the map together with areas that have been protected by riprap or other means. Other areas of natural and man-made activity are also shown on the map. The inspection write-ups describe each problem area in the pond and whether the area is actively eroding or in the process of healing.

On examining the records of the four inspections over 11 years, no pattern of increasing or decreasing of the erosion problem is evident. New problem areas are starting, some of the older ones are continuing and others are healing or have already healed over. NEPCO records show that almost 20% of the 91-mile shoreline of the Wilder Pool shows evidence of past or present erosion, but less than 5% appears to be actively eroding at any one time.

[1] NEPCO, due to litigation on the relicensing of their hydro projects, felt it expedient to release certain information from their files only to the study chairman, for analysis and reporting. Much of the remaining portion of this section dealing with Wilder Pool is based on that analysis.

One pattern is evident from NEPCO's inspection records. As a general rule, erosion seems to be most active on curved reaches and then usually on the outside of the curve (that is, the bank having the greater arc radius). This is important because it suggests that flow velocities in the pond are probably a factor causing erosion. Normally, an unimpeded stream will erode its banks in this manner. The higher velocities of the water going around the outside of a curve will tend to scour the outside bank. The lower velocities on the inside of the curve will permit sediment to fall out of the water, creating shoals.

This appears to be what is happening in the Wilder Pool, and perhaps it can be explained by the fact that Wilder Reservoir is very small when compared to the drainage that flows into it. The active storage at Wilder contains only the equivalent of 0.07 inches of runoff from the watershed. Under average river flow conditions, the inflow to the Wilder Pool would be enough to completely replace the reservoir storage in a little more than a day's duration. A normal spring inflow of 5 cubic feet per second per square mile (csm) would provide enough water to replace the active contents of the reservoir about 2-1/2 times a day. The small storage and large drainage of Wilder Pool means that the reservoir is acting somewhat like a free flowing stream. Stream velocities are scouring in some locations and depositing in others.

NEPCO examined a 45-mile, free-flowing reach of the Connecticut River between Lancaster and Stewartstown, New Hampshire. A photographic record was made of this area. The examination of the 45-mile reach of free-flowing river above Lancaster was undertaken in order to have a natural reach to compare with the controlled reach at Wilder. The twenty-five photographs taken on 10 May 1973 indicate that there are erosion problems, on the natural reach of river, similar to those in the Wilder Pool. NEPCO seems to feel that the erosion problems at Wilder are nothing that wouldn't have occurred if Wilder Dam was not in existence.

The evidence suggests that stream velocity is a factor in erosion at Wilder. The question now becomes, is it the only significant factor. We know that rapid reservoir drawdown can result in high hydrostatic pressures in the adjacent river banks and resulting bank sloughing. In the case of Wilder, we have a daily operational drawdown and refilling of the reservoir. The operating pool range is between 385 and 380 feet mean sea level. Reservoir operating curves (hydrographs) plotted once daily from 1963 to 1973 show that the pool has stayed within these limits except for one instance, from the 12th to the 14th of May 1972, when the pool was drawn to elevation 374 to search for a drowning victim. This extreme drawdown was done at the request of the New

Hampshire Fish & Game Department. Although the pool has a 5-foot range, it is unusual for the pool to be drawn down more than two to three feet in any one day. According to NEPCO, the turbines at Wilder, when working at capacity and with no reservoir inflow, would draw the pool down at the rate of .4 feet per hour. From the eleven years of hydrographs and records of two to three feet of normal fluctuation, it appears that this rate of drawdown is not normally exercised through the entire 5-foot active pool range. Records of pool levels are kept at the dam and cannot be applied to the upper reaches of the power pool. Levels at the upper reaches are influenced by inflows and are not wholly controllable by Wilder Dam. Through most of the year, the pool is operated in the upper three feet, between elevation 382 and 385. When high spring flows exceed the usable flow at Wilder, the pool is drawn down to and maintained at elevation 380. According to NEPCO, this drawdown is made to reduce the backwater effect of high flows upstream. This pool fluctuation probably caused an increase in bank sloughing for a short period after the project was constructed. The sloughing probably returned to its original rate after the streambank had adjusted itself to the new water level.

One other factor in the erosion problem is worth noting. Water levels in the 45-1/2 mile reach of Wilder Pool are usually higher than they would be had Wilder not been constructed. This means that erosion problems which the reach of river is now experiencing would probably be different than if Wilder had not been constructed. The water levels being higher means that the water is scouring the banks at a higher level. It is impossible to predict how this might change the patterns of erosion; however, in the judgement of several committee members, there is no reason to believe that this modified water level will change the magnitude of the erosion problem.

It is important to note that there is a natural hydraulic control in the Connecticut River at Gilman Island, about a mile upstream of Wilder Dam. As river flows get higher in flood stage, the constriction at Gilman Island begins to assume control of river levels upstream. At the time Wilder Dam was reconstructed, NEPCO developed backwater curves to compare the new dam (pool elevation 380) with the old dam (pool elevation 370). At a flow of 5,000 cfs, the new dam raises stages at the Ompompanoosuc River by 14 feet and at Waits River by 12.7 feet. At 41,000 cfs, the new dam raises levels at the Ompompanoosuc by 2.2 feet and at Waits River by 0.3 feet; at 60,000 cfs, the new dam raises levels at the Ompompanoosuc by 1.2 feet and at Waits River by less than 0.1 foot. With a flow of 91,000 cfs, levels at the Ompompanoosuc and Waits Rivers would be the same with the new or the old dam. To put these figures in perspective, average flow in the river at Wilder is about 5,800 cfs; the 1 July 1973 flood had a flow of 50,400 cfs[1] and the 1936 flood yielded a flow of 91,000 cfs[1]. The Ompompanoosuc River is 7.8 miles upstream of Wilder, and the Waits River is 30.3 miles upstream of Wilder.

This indicates that as flows increase beyond a certain point, Gilman Island begins to hydraulically control the river until a point is reached where Wilder Dam no longer has a significant effect on river stages upstream of Gilman Island.

Observations after unusually high river flows have indicated that the high flows have accelerated the rate of erosion. This would have been expected, but NEPCO and Soil Conservation Service people familiar with the river generally feel that extreme flows are responsible for most of the erosion in terms of total volume. Since river stages during extreme floods in most of Wilder Pool are little affected by the dam, it stands to reason that erosion caused by flows during the peak of a bad flood cannot be worsened by the dam. At periods of less than extreme floods, Wilder Dam does exert hydraulic control in the river above Gilman Island and the dam is certainly a factor in the erosion problem.

Waves are another factor in the erosion process. Waves are generated by wind conditions or boats or a combination of both. Natural waves in Wilder are small since the fetch in the long curvey pond is not enough to permit waves of a very high amplitude to be generated. Power boats on the other hand do produce larger waves. No attempt was made to compare the effect of an almost continual small natural wave action with the intermittent but larger wave action caused by boats. However, where wave action is the only erosive force acting on a bank, that bank will soon find its natural angle of repose and cease to erode. On the other hand, wave action will continue to slough banks that are continually undercut by a tractive erosion process. So, while waves might be the obvious reason for chunks of earth falling into the pond, we must look further to see why the chunk of earth was unstable before the wave hit it.

Poor land use practice is another obvious possible cause of erosion. Normally, we think of poor land use practice as a cause of sheet erosion; however, clearing trees and brush along a river bank will eliminate the root structure which goes a long way towards stabilizing the bank. Land clearing will, of course, accelerate runoff and can cause gulleys as the water runs into the river. These gulleys, in addition to carrying silt into the river will cause eddies which accelerate

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[1] Flood flows from NEPCO records.

erosion. Evidence of bank stripping can be seen in several locations and, as would be expected, erosion in these areas seems to be unusually bad. The information available is not adequate to make a quantative estimate of how much bank stripping is contributing to the total erosion problem.

One other factor must be considered in analyzing erosion in the Wilder Pool. The argument has been heard that since Wilder Pool presents a wider cross section of water in the river than would occur under natural conditions, then a given flow will have less velocity than it would under natural conditions. On the surface, this is true; but since the turbines draw 9,600 cfs of water when operating under full load, it must be remembered that flow in the pond near the dam is also 9,600 cfs decreasing upstream from the effects of storage until the flow is equal to the pond inflow at the extreme upstream end of the pool. So whether or not the dam and pond increase or decrease flow velocities from natural conditions is not a simple question. Average flows over a long period of time are, of course, not changed by the project and average flow velocity is decreased due to the increased cross sectional area of the pond. It is not felt that the project increases the tractive erosion process due to increased velocities.

In summarizing these findings, Wilder Pool seems to be typical of the three dams under study. Erosion at Wilder appears to be more extensive than at the other two dams, but the abundance of information gathered through the years on Wilder Pool may be the reason for this impression. In any case, this abundant information makes Wilder the best case for a detailed analysis.

Wilder does indeed have an erosion problem; about 20 percent of the reservoir shoreline shows signs of past or present erosion. New England Power Company has made rigorous inspections and reports on the problem in 1963, 1969, 1972 and 1973.

The pool shoreline erodes much like the banks would erode in a free flowing stream with scouring on the outside of curves and shoaling at the inside of curves, caused by the movement of water through the pond. The reservoir obviously causes erosion to take place at a higher level on the bank than would be the case if the dam had not been constructed. Based on the information available,[1] there is no clear indication that the magnitude of the erosion problem has been greatly affected by the existence of Wilder Dam.

NEPCO either owns outright or has secured flowage rights on virtually all the land which has been sloughing; however, development of land

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[1] See footnote on Page 4.

near the river has made bank sloughing a cause for concern in recent years. Much work has been done in recent years to protect the shoreline. The most notable example is a 10,000 foot reach of shoreline which was riprapped in Hanover, New Hampshire. If the banks are to be made secure from sloughing, much more bank protection must be anticipated in the future. Detailed soils investigations must be made to identify erosion prone banks.

Should the decision be made to let the banks continue in their present erosion patterns, then a detailed study must be made to identify what will be the problem areas in the future and then positive action must be taken to keep future development out of these areas. If this latter course of action is pursued, measures should be taken to remove structures from the existing problem areas or protect the shoreline near these structures from further erosion.

In view of the pressure to develop the shoreline of Wilder Pool, it seems imperative that studies be conducted to ascertain what land should be available for development and what shoreline should remain in natural state.

5. Environmental Considerations

It has been established within this report that erosion may be attributed to several causes including natural phenomena, poor land use practices, and possibly hydroelectric water level manipulation. If the Connecticut River is allowed to be a true riverine system and not a part-time lacustrine part-time riverine one, erosion may not be as serious a problem to the biological resources of the river. The "normal" process of silt carriage and deposition would continue. However, the river is manipulated on a continuous daily, weekly and seasonal basis. The eroded material appears to be deposited in a way that adversely affects the fishery resources. Benthic organisms may also be affected by the pattern of erosion.

6. Further Studies

The efforts of this study,have, for the most part, been directed to analyzing existing information and drawing whatever conclusions that are possible considering the nature and extent of the available information. Very little effort has been spent on collecting new data.

It has been found that adequate information is available so that an accurate assessment can be made of the extent of the erosion problem.

Sites of past and present bank sloughing have been identified, photograghed and mapped. The length, depth, area and volume of land lost have been recorded to an extent where a fairly accurate estimate of total erosion can be made.

Certain information gaps have become evident during the course of this study. The information which is available provides a pretty good picture of the history of erosion, but this information does not permit us to predict what erosion problems will occur in the future or how we might deal with these problems. Soils information in the detail necessary to deal with the erosion problem simply does not exist.

Development along the river now and in the past has been a hit or miss proposition. If a person guessed right, he had good shoreline property for his home; if he guessed wrong, his house fell into the river. An example of the latter case is the Charlestown, New Hampshire Wastewater Treatment Plant. In 1964, the town of Charlestown built its treatment plant on land acquired from NEPCO. NEPCO indicated its reservations about the property being suitable for development. The town felt that a site, some 120 feet from the river bank, would be safe. By 1968, the river had moved to within 85 feet of the plant; in 1971, the river was 66 feet away. Extrapolating we can see that the river will be undercutting the treatment plant in about 5 more years. The Corps of Engineers estimated in 1971 that $56,000 in bank protection was necessary to protect the $80,000 invested in the plant, constructed only 7 years earlier. This case is not unique, many homes are endangered now and many more will become endangered in the future as the river continues its natural meandering.

The U. S. House of Representatives, House Committee on Public Works, on 11 April 1974, adopted a resolution, requesting that the Corps of Engineers study erosion problems behind the Wilder, Bellows Falls, Vernon and Turners Falls Projects. The resolution which was introduced by Congressman Cleveland of New Hampshire states:

RESOLUTION

> "Resolved by the Committee on Public Works of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors is hereby requested to review the report on the land and water resources of the New England - New York Region, requested by the Flood Control Act of 1950 and published as Senate Document No. 14, Eighty-fifth Congress, First Session, to study the

erosion problems behind the Wilder, Bellows Falls, Vernon, and Turners Falls Dams and to make recommendations for any changes in the operation of the dams or such remedial measures as would minimize erosion in Wilder Lake and the banks of the Connecticut River downstream to Turners Falls in Massachusetts. The study should include any factors which might affect river bank erosion such as weathering, raising and lowering of lake levels, wave action, river velocities, sedimentation conditions, types of soils, frost effects, vegetation cover and root patterns."

The study envisioned consists of soils investigations, hydrologic studies, surveys and mapping, stream regulation studies, design and cost estimating, economic studies, real estate studies, and environmental studies. The end result would be a survey report which would make recommendations to Congress.

It has become evident that bank erosion is a serious problem in the area under study; it makes development along the shoreline of Vernon, Bellows Falls and Wilder Pools a hazardous undertaking. Development pressures on this desirable shoreline property will certainly increase in the future unless something is done. The study which has been authorized by the House Public Works Committee is necessary so that solutions to the erosion problem can be identified and recommended. Changes in the operation of the dams will be considered along with other remedial measures in the problem areas. Certain erosion prone areas might be identified with recommendations that they be zoned out of development. In other cases, shoreline protection might be the answer. Whatever the case, before action is taken, the cost must be determined; the cost in dollars, the cost to the environment, and the social costs to the people that would be affected.

7. Conclusions and Recommendations

The conclusions and recommendations, based on this report, must first be qualified by the conditions under which the study was undertaken. The study has been a two-month long unfunded reconnaissance effort by six Federal Agencies, two states and one private company. The study has taken place in the winter months of January, February and March 1974, so that a minimum of field investigation was possible. The little field investigation that was undertaken was not as effective as it would have been during the summer months.

Conclusions

A. There is a widespread bank erosion problem in the 121.0 mile reach of Connecticut River between Vernon Dam and the headwaters to the Wilder reservoir on both the New Hampshire and Vermont shoreline. Land of stream abutters is being lost. Silting due in part to this bank erosion, has an adverse effect on the river's fish population, water quality, and aesthetics.

B. This problem can be expected to continue at about the present rate with a gross[1] rate of some 32 acres or 350,000 cubic yards of earth lost annually. Some existing problem areas will continue to erode, some will heal and new areas of erosion can be expected to develop.

C. The three hydroelectric projects do modify the erosion patterns from what would be a natural situation. There is, however, no clear evidence that the magnitude of the erosion problem has or has not been greatly changed by the construction and operation of the three projects.

D. Several information gaps have become evident during the course of the study. While the extent of the existing erosion problem is generally evident, the forces which cause the problem are not well understood. Soils information is not adequate and not enough is known about flow patterns in the river both in normal and flood conditions. More should be learned about the effects of erosion on the river's biota, especially with regards to silting. Information is not available on the sources of depositions in the river; for instance, we don't know the relation of shoaling to erosion.

[1] It is recognized that while some bank is being lost to the erosion process, siltation or shoaling is creating new land. No attempt has been made to estimate the amount of new land being created by this shoaling.

Recommendations

A. That detailed soils, engineering, economic and environmental studies be conducted to determine and map exactly which areas along the shoreline of the Connecticut River are erosion prone. Dollar, social and environmental benefits and costs of providing bank protection, zoning, or making reservoir operational changes should be developed and compared.

B. That the appropriate states and communities should develop or adjust their master plans and zoning ordinances to reflect the findings of the study mentioned in Recommendation A.

C. That the question of streambank erosion, having certain environmental implications, should be addressed by the Federal Power Commission in its preparation of an Environmental Impact Statement for the Vernon, Bellows Falls and Wilder project relicensings.

D. The relicensing procedures for the three dams should proceed as presently scheduled, and not be delayed pending completion of studies recommended under "A" above.

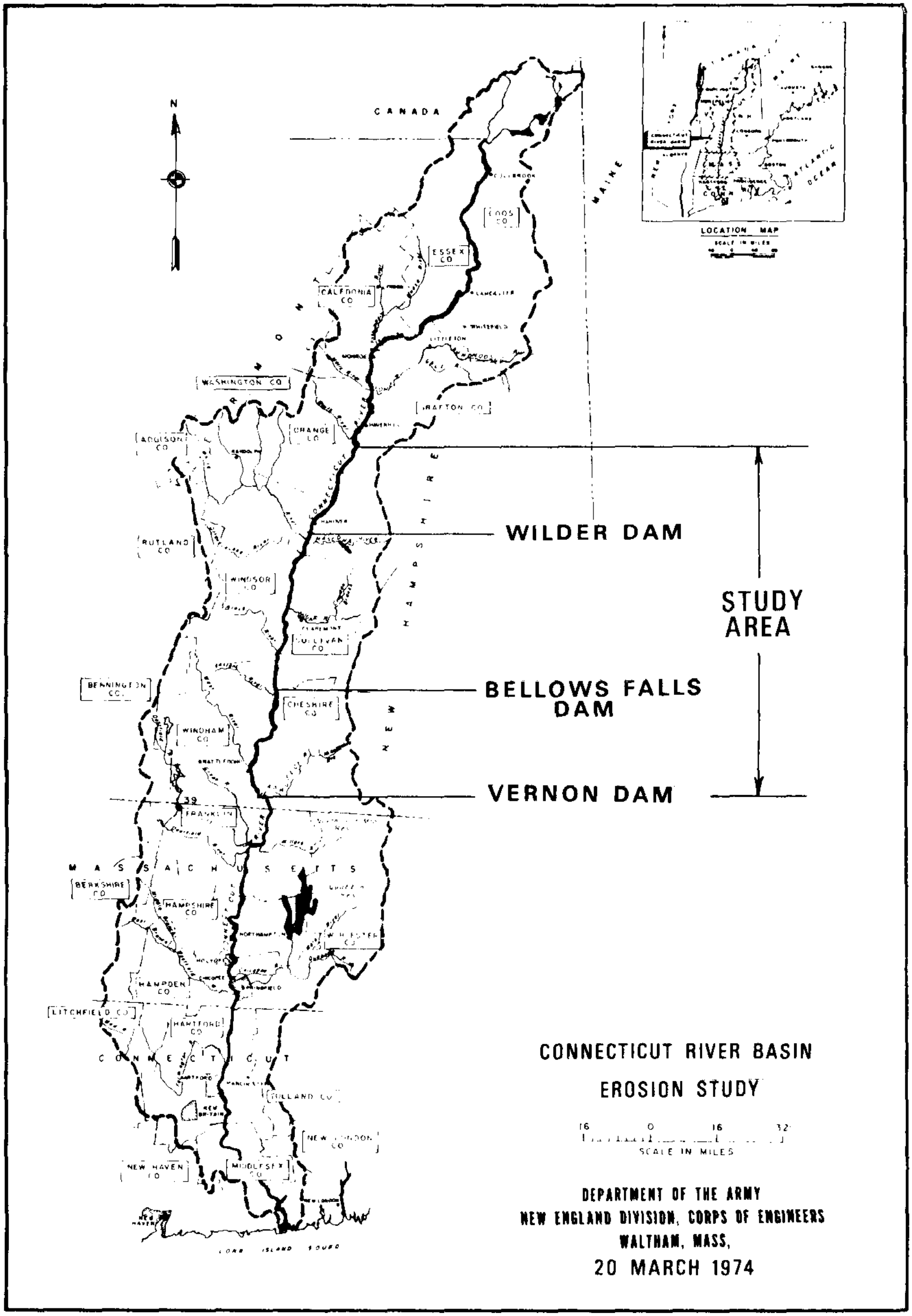

CANADA
MAINE
N
LOCATION MAP
WILDER DAM
BELLOWS FALLS DAM
VERNON DAM
STUDY AREA
NEW HAMPSHIRE
MASSACHUSETTS
CONNECTICUT
ESSEX CO
CALEDONIA CO
WASHINGTON CO
GRAFTON CO
ORANGE CO
ADDISON CO
RUTLAND CO
WINDSOR CO
SULLIVAN CO
BENNINGTON CO.
CHESHIRE CO
WINDHAM CO
FRANKLIN
BERKSHIRE CO
HAMPSHIRE CO
HAMPDEN CO
LITCHFIELD CO
HARTFORD CO
TOLLAND CO
NEW LONDON CO
NEW HAVEN CO
MIDDLESEX CO
CONNECTICUT RIVER BASIN
EROSION STUDY
16 0 16 32
SCALE IN MILES
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.
20 MARCH 1974

Figure 1

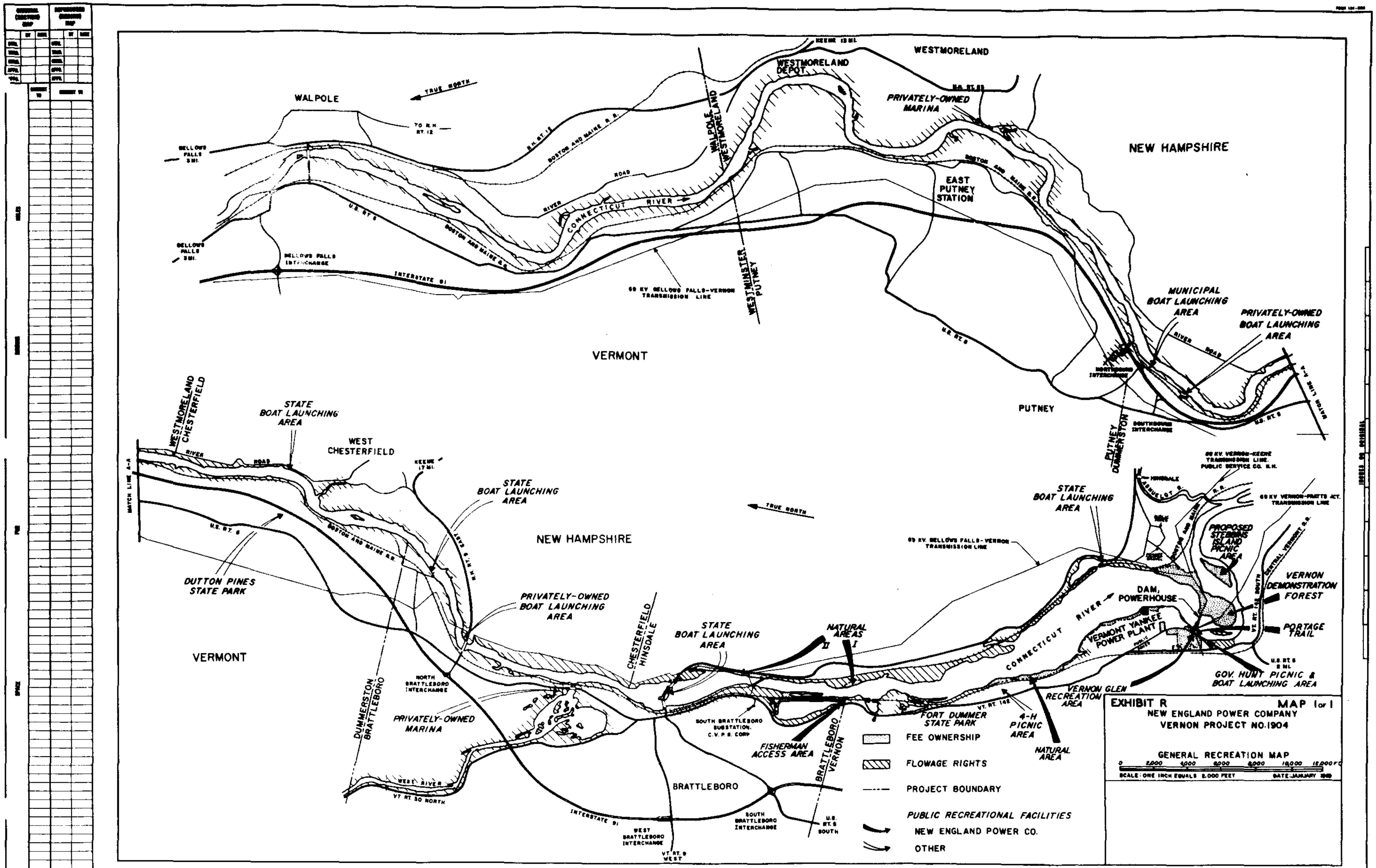
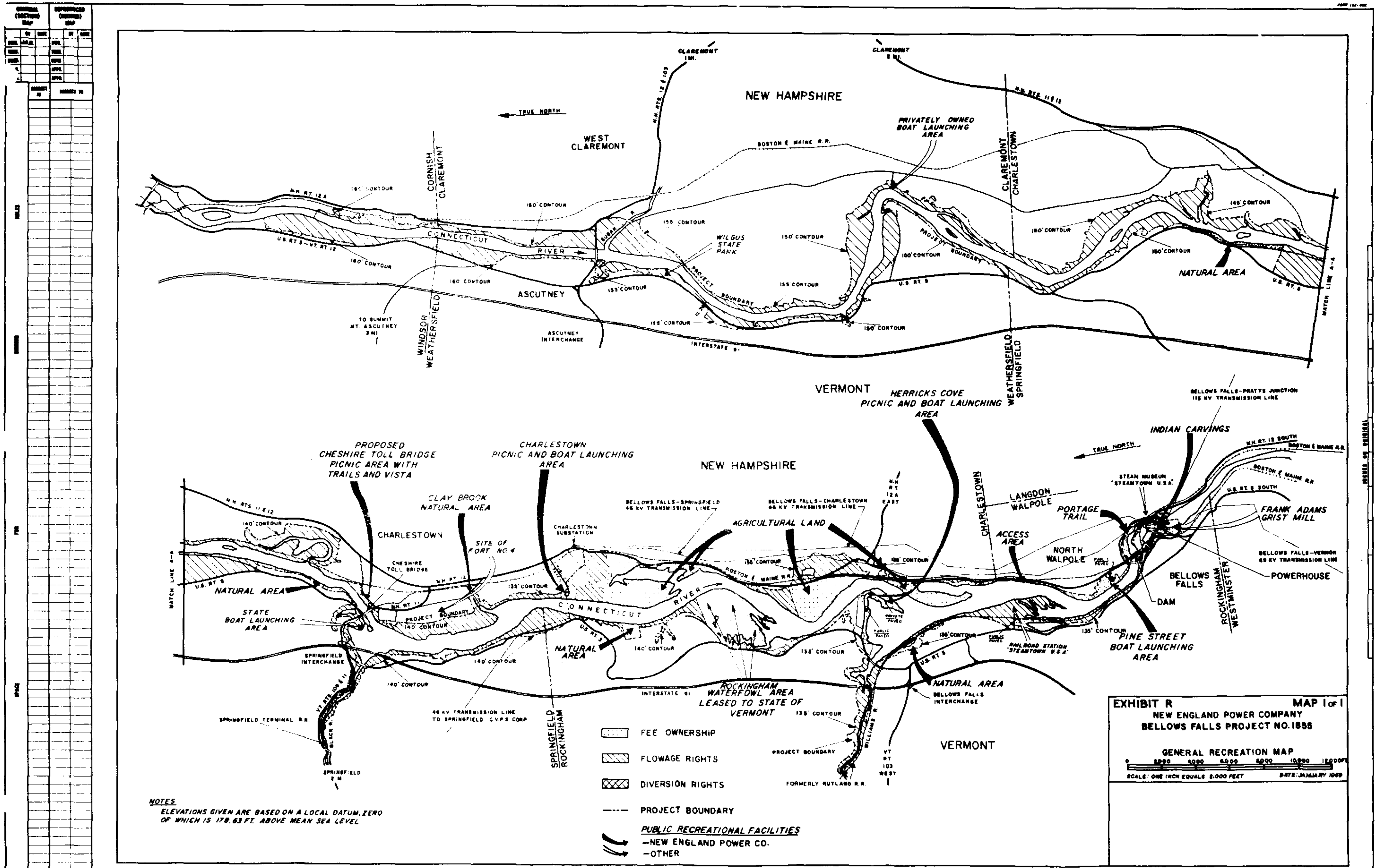

WESTMORELAND
WALPOLE
WESTMORELAND DEPOT
PRIVATELY-OWNED MARINA
NEW HAMPSHIRE
TRUE NORTH
WALPOLE WESTMORELAND
EAST PUTNEY STATION
CONNECTICUT RIVER
BOSTON AND MAINE R.R.
U.S. RT. 5
INTERSTATE 91
BELLOWS FALLS INTERCHANGE
69 KV BELLOWS FALLS-VERNON TRANSMISSION LINE
WESTMINSTER PUTNEY
MUNICIPAL BOAT LAUNCHING AREA
PRIVATELY-OWNED BOAT LAUNCHING AREA
RIVER ROAD
VERMONT
PUTNEY
PUTNEY DUMMERSTON
MATCH LINE A-A
WESTMORELAND CHESTERFIELD
STATE BOAT LAUNCHING AREA
WEST CHESTERFIELD
STATE BOAT LAUNCHING AREA
NEW HAMPSHIRE
DUTTON PINES STATE PARK
PRIVATELY-OWNED BOAT LAUNCHING AREA
CHESTERFIELD HINSDALE
STATE BOAT LAUNCHING AREA
NATURAL AREAS
VERMONT
DUMMERSTON BRATTLEBORO
PRIVATELY-OWNED MARINA
BRATTLEBORO
BRATTLEBORO VERNON
FISHERMAN ACCESS AREA
FORT DUMMER STATE PARK
4-H PICNIC AREA
NATURAL AREA
VERNON GLEN RECREATION AREA
STATE BOAT LAUNCHING AREA
DAM, POWERHOUSE
VERMONT YANKEE POWER PLANT
PROPOSED STEBBINS ISLAND PICNIC AREA
VERNON DEMONSTRATION FOREST
PORTAGE TRAIL
GOV. HUNT PICNIC & BOAT LAUNCHING AREA
HINSDALE
FEE OWNERSHIP
FLOWAGE RIGHTS
PROJECT BOUNDARY
PUBLIC RECREATIONAL FACILITIES
NEW ENGLAND POWER CO.
OTHER
EXHIBIT R
MAP 1 of 1
NEW ENGLAND POWER COMPANY
VERNON PROJECT NO.1904
GENERAL RECREATION MAP
SCALE: ONE INCH EQUALS 2,000 FEET

PLATE 1



NEW HAMPSHIRE
VERMONT
TRUE NORTH
WEST CLAREMONT
CORNISH
CLAREMONT
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WEATHERSFIELD
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WEATHERSFIELD
SPRINGFIELD
CONNECTICUT
RIVER
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N.H. RTS. 11 & 12
BOSTON & MAINE R.R.
INTERSTATE 91
PRIVATELY OWNED BOAT LAUNCHING AREA
WILGUS STATE PARK
PROJECT BOUNDARY
NATURAL AREA
MATCH LINE A-A
TO SUMMIT MT. ASCUTNEY 2 MI
ASCUTNEY INTERCHANGE
160' CONTOUR
155' CONTOUR
150' CONTOUR
145' CONTOUR
HERRICKS COVE PICNIC AND BOAT LAUNCHING AREA
PROPOSED CHESHIRE TOLL BRIDGE PICNIC AREA WITH TRAILS AND VISTA
CHARLESTOWN PICNIC AND BOAT LAUNCHING AREA
CLAY BROOK NATURAL AREA
SITE OF FORT NO. 4
CHARLESTOWN
CHESHIRE TOLL BRIDGE
CHARLESTOWN SUBSTATION
BELLOWS FALLS - SPRINGFIELD 46 KV TRANSMISSION LINE
BELLOWS FALLS - CHARLESTOWN 46 KV TRANSMISSION LINE
AGRICULTURAL LAND
LANGDON
WALPOLE
NORTH WALPOLE
ACCESS AREA
PORTAGE TRAIL
INDIAN CARVINGS
BELLOWS FALLS - PRATTS JUNCTION 115 KV TRANSMISSION LINE
STEAM MUSEUM "STEAMTOWN U.S.A."
FRANK ADAMS GRIST MILL
BELLOWS FALLS - VERNON 69 KV TRANSMISSION LINE
POWERHOUSE
BELLOWS FALLS
DAM
ROCKINGHAM
WESTMINSTER
PINE STREET BOAT LAUNCHING AREA
RAILROAD STATION "STEAMTOWN U.S.A."
BELLOWS FALLS INTERCHANGE
STATE BOAT LAUNCHING AREA
SPRINGFIELD INTERCHANGE
SPRINGFIELD TERMINAL R.R.
SPRINGFIELD 2 MI
46 KV TRANSMISSION LINE TO SPRINGFIELD C.V.P.S. CORP
SPRINGFIELD
ROCKINGHAM
ROCKINGHAM WATERFOWL AREA LEASED TO STATE OF VERMONT
FORMERLY RUTLAND R.R.
VT RT 103 WEST
140' CONTOUR
135' CONTOUR
FEE OWNERSHIP
FLOWAGE RIGHTS
DIVERSION RIGHTS
PROJECT BOUNDARY
PUBLIC RECREATIONAL FACILITIES
—NEW ENGLAND POWER CO.
—OTHER
NOTES
ELEVATIONS GIVEN ARE BASED ON A LOCAL DATUM, ZERO OF WHICH IS 178.63 FT. ABOVE MEAN SEA LEVEL
EXHIBIT R
MAP 1 OF 1
NEW ENGLAND POWER COMPANY
BELLOWS FALLS PROJECT NO. 1855
GENERAL RECREATION MAP
SCALE: ONE INCH EQUALS 2,000 FEET
DATE: JANUARY 1969

PLATE 2

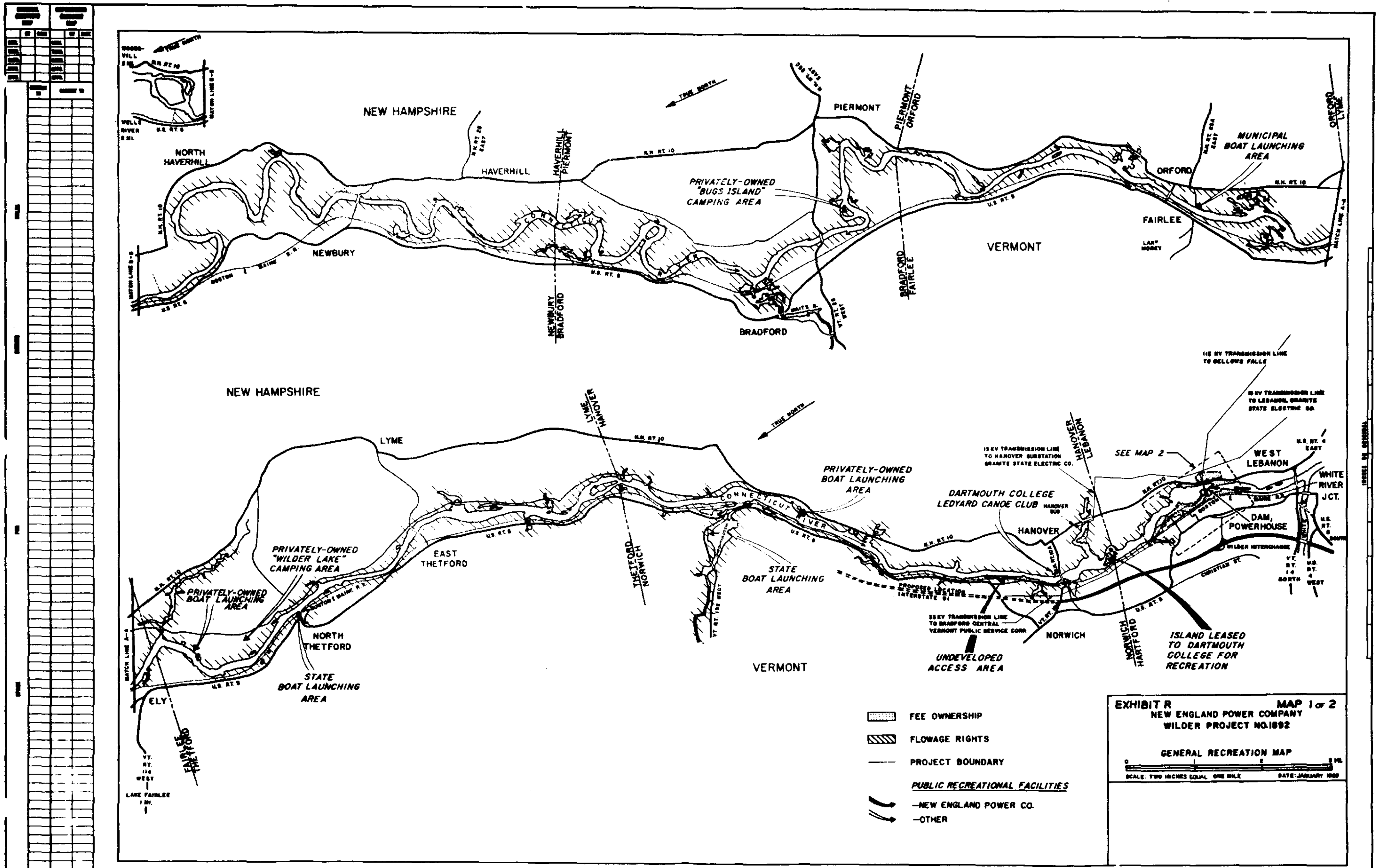
NEW HAMPSHIRE
TRUE NORTH
NORTH HAVERHILL
HAVERHILL
HAVERHILL
PIERMONT
N.H. RT. 10
NEWBURY
NEWBURY
BRADFORD
U.S. RT. 5
BOSTON & MAINE R.R.
BRADFORD
PIERMONT
PIERMONT
ORFORD
PRIVATELY-OWNED
"BUGS ISLAND"
CAMPING AREA
BRADFORD
FAIRLEE
VERMONT
MUNICIPAL
BOAT LAUNCHING
AREA
ORFORD
ORFORD
LYME
FAIRLEE
NEW HAMPSHIRE
LYME
LYME
HANOVER
TRUE NORTH
PRIVATELY-OWNED
BOAT LAUNCHING
AREA
CONNECTICUT RIVER
DARTMOUTH COLLEGE
LEDYARD CANOE CLUB
HANOVER
HANOVER
LEBANON
SEE MAP 2
WEST
LEBANON
WHITE
RIVER
JCT.
DAM,
POWERHOUSE
PRIVATELY-OWNED
"WILDER LAKE"
CAMPING AREA
EAST
THETFORD
PRIVATELY-OWNED
BOAT LAUNCHING
AREA
NORTH
THETFORD
STATE
BOAT LAUNCHING
AREA
THETFORD
NORWICH
STATE
BOAT LAUNCHING
AREA
UNDEVELOPED
ACCESS AREA
NORWICH
NORWICH
HARTFORD
ISLAND LEASED
TO DARTMOUTH
COLLEGE FOR
RECREATION
VERMONT
ELY
FAIRLEE
THETFORD
FEE OWNERSHIP
FLOWAGE RIGHTS
PROJECT BOUNDARY
PUBLIC RECREATIONAL FACILITIES
—NEW ENGLAND POWER CO.
—OTHER
EXHIBIT R
MAP 1 OF 2
NEW ENGLAND POWER COMPANY
WILDER PROJECT NO.1892
GENERAL RECREATION MAP

PLATE 3

MEETING SUMMARY

CONNECTICUT RIVER BANK EROSION STUDY

31 January 1974

SUBJECT: Summary of the Meeting 31 January 1974 of the Technical Committee on Bank Erosion in Connection with the Connecticut River Dam Re-Licensing

1. The meeting began with an introduction by Colonel Mason who explained, in essence, the mission of the committee was to provide a report to the 20 March NERBC meeting with respect to the nature of the erosion problem, the apparent causes of the erosion problems, relationships to relicensing, and any recommendations which the committee may wish to offer to assist us in resolving the problem. He then noted that John T. Smith, of his Planning staff, would represent him as a member on the technical committee.

2. John Smith distributed a copy of the agenda for the day, copy of which is attached, along with the attendance for the meeting. After the attendees had each introduced himself, the scope of the study and the study area was discussed as follows:

At the December New England River Basins Commission quarterly meeting, Mr. James Minnoch from New Hampshire submitted a motion to authorize Mr. Gregg to appoint a small study group from various organizations to assess bank erosion problems at three hydroelectric dams (Vernon, Bellows Falls, and Wilder) which are up for relicensing. The motion was passed by the Commission; and Mr. Gregg, by memorandum, asked the Corps to chair the study. The memorandum, which Mr. Gregg sent to the Corps, was attached to the letters of invitation sent to those participating. It was noted that New Hampshire is particularly interested in the problems at the three plants. New England Power Company owns all three plants. The Federal Power Commission is the licensing authority for these plants, and to date FPC has not acted on the application.

3. Apparently, there is a problem of bank sloughing in the power pools of the plants and the Commission has specifically asked that the study respond to three areas: (1) extent and nature of the problem; (2) relationship with the relicensing of the New England Power Company Dams and (3) recommendations to resolve the problem.

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Attachment 1

4. Under scheduling and reporting, Agenda Item 3, there was considerable discussion as to the short-term nature of the work of the committee, and the fact that everything would have to be done expeditiously if we were to be able to report at the 20 March NERBC Quarterly Meeting. It was pointed out that the Committee would only have time to make a list of the kinds of information that are available -- who has it, where is it, and what the extent of that information is. This information would be provided in the form of reports from each of the participating agencies; specifically, the Corps, SCS, Bureau of Sport Fisheries and Wildlife, and EPA. The States and other Federal agencies, and the New England Power Company were invited to submit reports if they wished. At this stage in the meeting, it was not certain as to what kinds of information were available. It was decided to wait until agenda item 5 was discussed before setting schedule dates. We then moved on to agenda item 4.

5. Under agenda item 4, John Smith and Hank Baker, NED Soils Engineer, discussed the general forms of bank erosion, which may be taking place. They generally break down into two categories -- those caused by natural flows, stream velocity, or those caused by fluctuation of the pool. It was noted that both are natural processes which go on continually to some extent in all streams. In the first category, high velocities caused by flood flows accelerate this process. The material is literally gouged off the stream bank. In the second type, the erosion is caused by rapid changes in reservoir or stream level. When the water level is drawn down fast, the stream level becomes lower than the corresponding groundwater level in the adjoining bank, and the water which is stored in the bank then flows out under pressure into the stream. If the head on the groundwater is abnormally high, then the velocities through the soil of the bank are very high and the fine particles are washed out and weaken the structure of the soil. The weight of heavy rain falling on a bank already undercut by an erosion process can cause that bank to fail.

6. Under agenda item 5, Exchange of Information, Ed Plumley of New England Power noted that his company had applied for some six years for a long-term license for the three plants and various interests had intervened in the application for relicensing. Because of the intervention and the fact that intervenors are present on the committee, the New England Power Company does not wish to jeopardize its legal position with respect to the FPC decision on relicensing. In response, Larry Dingman noted that he had resigned as a director of For Land's Sake early in December and that he is still a member. For Land's Sake is an intervenor in the relicensing of the three hydro plants. Also,

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Dr. Brower noted that although she is representing the Science Advisory Group, she does also represent the Massachusetts Public Interest Research Group which is an intervenor. In essence, then, there was a question on the release of technical data, and Ed noted that he would check with the company attorney before making a decision on which information their firm could release.

7. James Minnoch, Office of State Planning of New Hampshire, speaking for the State, felt that a technical study of the erosion problem is needed. He felt that there is sufficient data necessary to preclude extensive study and that the main interest is to assure that New Hampshire is well coordinated on the problem. He feels that the findings of the technical committee could be used in the public hearings on the relicensing. Mr. Grob of the FPC noted that formal hearings with respect to the relicensing are planned, but as yet are not scheduled.

8. There was considerable discussion as to the extent and nature of the information which is currently available. In summary, the following information was noted:

a. The Connecticut River Basin report contains a general position on the overall effect of erosion and sedimentation in the basin. Erosion is discussed in Appendix F.

b. In 1969, the Corps and SCS made an erosion assessment which has some generalized information on erosion but nothing of any detail that would be helpful in our study.

c. Photos -- there are 1969 photos of I-91 at 1" = 2,000'. CRREL - the Cold Regions Resource Engineering Laboratory has 1973 photos of sloughing areas in Wilder Pool. They also have low level aerial obliques when the pool was drawn down in 1973, some eight feet. There are a series of vertical photos or photogrammetry of the basin, dating back as early as 1939. Vermont has 1962 photos at 1" = 1,500', and 1969 photos of southern Vermont at 1" = 2,000'. Vermont also has photos of I-91, five foot contours 1" = 200' -- all the way up to St. Johnsbury, and also some old file photos which could be looked at to see whether they are pertinent. As to the usefulness of photos, there was some doubt as to whether the photos would be helpful in determining the extent of the erosion.

R 5/1/74

d. Soil Mapping -- The Soil Conservation Service has extensive soil mapping which is oriented to agricultural use dealing with the top four to five feet of over-burden. Since 1950, the soil has been classified in two different ways -- one primarily agricultural, and the second on a general scientific sense. The entire New Hampshire shoreline is done on the old method, by counties, and several portions have also been done by the new methods. Soil types were done for Vermont for the CRB Study and land use classifications are available. Keith MacPherson of SCS noted that he would ask the SCS county agents to prepare report information for him.

9. George Morrison of the New Hampshire Fish and Game said that he would cooperate with Peggy Kohl of U. S. Fish and Wildlife in providing information to the committee. Morrison's office has extensive raw data on the river, although it hasn't been developed in a form which would lend itself to submission to the committee. In reference to delineating the extent of the erosion, he felt that the only way to really view the river banks is by boat and by water. He did not feel that the aerial photos would lend much help and he stated that the highways did not go close enough to the river bank in enough places to be helpful in the overall problem. Larry Dingman felt that you could get an idea of the overall extent by examining the photos, but you would have to make a field inspection to determine the nature of the problem. Ed Plumley of New England Power noted that his office has extensive records of the operation of the pools which will be essential in the determination of the nature of the problem. He said much of this information is already available in the New England Division office. He felt we needed to compare the natural stream condition with artificial conditions imposed by the reservoirs. Jim Kohler of EPA felt that a number of questions ought to be responded to. They dealt with the fluctuation of the pool, the groundwater response to fluctuation, soil type saturation condition, the seasonal affect of erosion, seasonal occurrence of erosion and the silt or sedimentation load in the river. Hank Baker felt that where For Land's Sake had been an intervenor in the relicensing because of the erosion problem, we ought to get a copy of their statement to FPC. Dr. Brower felt that the statement provided by For Land's Sake would be too general to be helpful to a detailed study.

10. At the close of the meeting, John Smith summarized the accomplishments of the meeting and after some discussion it was agreed that the agencies would provide their reports to John by 20 February. John would then compile the reports, coordinate them and submit them to the participants for review; and then, by 20 March, agencies would have provided their comments by telephone so that he could report to NERBC on that date.

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Attachment 1

EROSION STUDY MEETING

31 January 1974

AGENDA

10:00 a.m.

I. INTRODUCTIONS

II. SCOPE OF THE STUDY AND THE STUDY AREA

III. SCHEDULING AND REPORTING

IV. EROSION IN GENERAL

V. INFORMATION EXCHANGE

(Since the study is to be carried out in one month, it is important to make as much information as possible available to all study participants at the onset of the study. Therefore, everybody is asked to contribute whatever information they have pertinent to the erosion problem at the three hydro pools).

VI. CONCLUSIONS - ADJOURN

Attachment 1

Meeting 31 January 1974

CONNECTICUT RIVER EROSION STUDY

Attendance

Name	Organization
John H. Mason	NED, Corps of Engineers
Larry Bergen	NED, Corps of Engineers
Hank Baker	NED, Corps of Engineers
John Smith	NED, Corps of Engineers
Bob Wernecke	Vermont
James Minnoch	New Hampshire
George Morrison	New Hampshire Fish & Game
Edward Plumley	New England Power Company
Armand Milette	New England Power Company
Howard Stockwell	New England Power Company
Dave Campbell	New England Power Company
Milt Anderson	New England Power Company
Larry Dingman	~~K~~ New England River Basins Commission
Jane Brower	Connecticut River Supplemental Study Science Advisory Group
James Kohler	Environmental Protection Agency
Raymond Grob	Federal Power Commission
Peg Kohl	U. S. Bureau of Sport Fishery & Wildlife
Keith MacPherson	Soil Conservation Service

Attachment 1

CONNECTICUT RIVER BANK EROSION STUDY

REPORT FINALIZATION MEETING

WALTHAM, MASSACHUSETTS - 18 APRIL 1974

ATTENDANCE LIST

John T. Smith, Corps of Engineers, Chairman

Milton A. Anderson, New England Power Company

Jane V. Brower, New England River Basins Commission, Science Advisory Group

David R. Campbell, New England Power Company

S. Lawrence Dingman, New England River Basins Commission

John C. Hart, Corps of Engineers

Martin Inwald, Federal Power Commission

Margaret A. Kohl, U. S. Bureau of Sport Fisheries & Wildlife

James A. Kohler, U. S. Environmental Protection Agency

Keith MacPherson, U. S. Soil Conservation Service

George R. Morrison, New Hampshire Fish and Game

Edward A. Plumley, New England Power Company

Howard E. Stockwell, New England Power Company

Robert Wernecke, Vermont Department of Water Resources

Attachment 2

BANK EROSION STUDY

CONNECTICUT RIVER

NEW HAMPSHIRE & VERMONT

UNITED STATES

DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

FEBRUARY 1974

APPENDIX A

BANK EROSION STUDY
CONNECTICUT RIVER

This report summarizes information on the extent of significant bank erosion along the 95 mile reach of the Connecticut River between Vernon Dam and the headwaters of the power pool at Wilder Dam.

The information presented was provided by the Soil Conservation Service personnel from each of the 6 counties abutting the reach of river under consideration. The information shows that portion of the river, located between Vernon Dam on the south and Woodsville, New Hampshire, on the north, which has a total length of 51 miles of eroded river bank. Of this total 28 miles of eroding bank are on the easterly, or New Hampshire, side of the river. The remaining 23 miles are located on the westerly, or Vermont side.

The data submitted was obtained from field reconnaissance surveys, measurements from aerial photographs, field surveys, and interviews with landowners. The data is varied in both amount and degree of detail because of the availability of personnel to gather the data within the limited time. Weather and snow cover also hindered the gathering of data to some extent. Summaries of the data received from each of the six counties follows:

Cheshire County, New Hampshire:

Cheshire County has approximately 35 miles of frontage on the Connecticut River north of Vernon Dam. Of this total the 7 miles between Vernon Dam and the Route 9 crossing has little or no bank erosion. The remaining 28 miles to the north of Route 9 has 20 areas of significant bank erosion ranging from 200 to 6350 feet in length and from 2 to 30 feet in height. The location of each of these areas is shown on Exhibits 1-1 through 1-3. Detailed information pertaining to the length, height, and type of soil for each section of the eroded bank is contained in Table 1. Soil Survey Interpretations for each soil type are shown in Exhibits 3-1, 3-3 and 3-4.

With the exception of Location No. 12, no dimensions for the depth of bank lost were included in the data from Cheshire County. The information did show that 10 to 15 feet of bank has been lost at Location No.12 over a period of 17 years. Based on these dimensions and the height and length of bank shown in Table 1 for this location, the estimated losses in both volume of soil and area, ranges from 1925 c.y. and 0.02 acres to 2890 c.y. and 0.03 acres. The degree of change that has taken place over the 17 year period is illustrated by the photographs in Exhibit 2-1.

Sullivan County, New Hampshire:

Reconnaissance of the 36 miles of the Connecticut River located within the boundaries of Sullivan County shows that approximately 59,400 feet or approximately 11 miles of river bank are eroding to some degree.

The most severe erosion is occurring south of Route 103 at locations 21 through 28. At these locations the banks are vertical or nearly vertical as illustrated in Exhibit 4-1 and range from 4 to 40 feet in height.

Although annual losses for the eroding areas in this reach range from minimum values of 1 to 2 feet up to maximum values of 5 to 7 feet, losses up to 15 feet are not uncommon. One farmer reported that he lost 7 rows of corn plus a buffer strip adjacent to the edge of the bank this past year.

North of Route 103 the erosion is not as apparent, nor is it as severe at Locations 29, 31, 34 and 35 where the banks are vertical or nearly vertical. This may be in part due to the fact that the banks at Locations 30, 32, 33 and 36 through 37 slope into the channel as illustrated in Exhibit 5-1. Better vegetative cover may also contribute to the reduced erosion north of the Route 103.

The locations of the areas of eroding river bank within the boundaries of Sullivan County are shown on Exhibits 1-3, 1-4, and 1-5. Table 2 shows the dimensions eroding bank at each location. It also shows the volume of material and area lost annually as well as the type of soil for each location. Soil Survey Interpretations for each soil type are shown in Exhibits 3-1, 3-3, 3-4, 3-6, and 3-16.

Grafton County, New Hampshire

Reconnaissance of the 52 miles of the Connecticut River between the Sullivan-Grafton County line and Howards Island shows that at 49 locations severe bank erosion is taking place. The total length of eroded bank is 52,900 feet, or approximately 10 miles. In addition to these severely eroding areas, numerous raw areas dot the bank. No attempt was made to tally these areas as they are characteristic of almost the entire river bank. The severly eroded areas are located by number on Exhibits 1-5 through 1-8.

Table 3 shows the length, the average height, the soil type, and the soil description for each location. Exhibits 3-1 through 3-5, 3-7, 3-13 through 3-16, provide the Soil Survey Interpretations for the types of soils.

The following comments,for the eroded areas indicated, were also included with the information from Grafton County:

Location No.	Remarks
40-46	Wooded area
47, 49, 50	Wooded area
48	Below CRREL, may have started from gravel operation at top edge of slope
51	Half wooded, half hayland
52	Hayland and 15 year old Christmas tree plantation
53	Town road has been threatened and undermined
54	Recreation area with lawn to river bank, one small gully
55-57	Banks covered with ice - information from owner
58	Wooded
59	Includes small gully on area repaired 5 years ago
60, 61	Hayland
63	2 to 3 acres has been lost over the past 5 years
64	Residential land use
65, 67	Hayland

Location No.	Remarks
68	Pasture
69	Hayland, one small gully has been repaired.
* 71	Semi-eroded hayland bordered by large trees on river bank, large crack located 2 to 8 feet back from the edge of the bank runs almost the entire length of the field. This crack was evident before 1973 flooding
72	Pasture and wooded area
73	Hayland
* 74	Conditions similar to those at Location 71
75	River almost cut off an old oxbow leaving an island - 2-3 acres lost
76	Hayland, severely eroded, lost 2 acres prior to 1973 floods
77	Pasture
78	Hayland
79	Lost about 40,000 c.y. of soil during June flood. Severe erosion due to heavy overgrazing
80	Hayland
81	Wooded
82	Hayland
83	Pasture
84	Crops and hay
86	Corn
87	Heavy hardwood trees along top of bank - top is severely cracked
89	Small gully needs repair - river bank has eroded again.

* Using the lengths and heights of eroded bank,for locations 71 and 74, from Table 3, and the distances from the edge of bank to the cracks shown above,the potential losses of volumes of material and areas range from 1850 c.y. and 0.11 acres to 7410 c.y. and 0.46 acres for Location 71 and from 1260 c.y. and 0.08 acres to 5040 c.y. and 0.31 acres for Location 74.

Windham County, Vermont

Windham County has approximately 40 miles of frontage on the Connecticut River between Vernon Dam and the Windham-Windsor County line. Although the information furnished did not include any estimate of the depth of bank, the volume of material or the areas lost for any specific locations, it did show that there is a total length of 21,400 feet or approximately 4 miles of 10 to 15 feet high bank showing signs of significant erosion. (Exhibits 1-1, 1-2, and 1-3.) Soil Survey Interpretations for the Agawam and Hadley soils found in this reach are shown in Exhibits 3-1, 3-3 and 3-4.

Windsor County, Vermont

Reconnaissance of the 45 miles of the Connecticut River bank located within the boundaries of Windsor County, shows approximately 75,900 feet, or approximately 14 miles of eroding bank. Individual areas, within this 75,900 feet, range from 660 to 6600 in length and from 2.5 to 25 feet in average height.

As shown by Table 4 the information on lengths of eroding bank is classified by both average height and type of soil on a town by town basis. Although the specific areas of bank erosion cannot be pinpointed on Exhibits 1-3 through 1-7 the locations are separated by towns. The range of annual loss of depth of bank, volume of material, and area for each segment of eroding bank, are also shown in Table 4.

Orange County, Vermont

Reconnaissance of the 38.5 miles of the Connecticut River located to the north of the Windsor-Orange County line shows that severe bank erosion is taking place at 28 Locations. The total length of eroded bank is 26,250 feet or approximately 5 miles.

The information furnished included length of bank, average height of bank, area lost annually, and the type of soil for each location. Table 5 shows this information plus the computed depth of bank loss annually. The depth of bank lost for each location was determined from the length of eroded bank and area lost for each location.

The location of each section of eroded bank is shown on Exhibits 1-7 and 1-8. The Soil Survey Interpretations for the soil types are shown in Exhibits 3-1, 3-3 and 3-4

Three of the reporting counties had common comments in their reports. Each county reported that banks having large trees growing either on the face or along the top of the bank appear to be more susceptible to erosion than those with grass, brush, small trees.

Each county reported numerous instances of gouging,of steeply sloping banks, by ice cakes. One county reported the personnel had observed ice cakes gouging up to 10 feet into the river banks. They also reported numerous instances of bank failure after large clods of frozen soil removed when cakes of anchor ice broke away from the banks, as illustrated in Exhibit 6.

TABLE - 1

CONNECTICUT RIVER BANK EROSION STUDY

Cheshire County, New Hampshire

Location No.	Length of Eroded Bank FT	Height of Eroded Bank FT	Soil Type	Soil Description				
1	3200	5	Hadley	v.f.s.l.				
2	200	10	Hadley	v.f.s.l.				
3	300	20	Hadley	v.f.s.l.				
4	2150	5-10	Hadley	v.f.s.l.				
5	200	15	Hadley	v.f.s.l.				
6	400	10	Hadley	v.f.s.l.				
7	880	10	Hadley	f.s.l.				
8	2280	15	Hadley	f.s.l.				
9	1050	20	Hadley	f.s.l.				
10	4550	2-10	Hadley	f.s.l.				
11	5280	2-10	Agawam	f.s.l.				
12	1300	20	Hadley	v.f.s.l.	Low Bottom			
13	6350	5-10	Hadley	v.f.s.l.	Low Bottom			
14	1700	5	Agawam	l.f.s.	(80% of bank gone)			
15	1000	10	Hadley	v.f.s.l.	Low Bottom			
16	1530	30	Hadley	v.f.s.l.				
17	3400	5-20	Hadley	v.f.s.l.				
18	300	5	Hadley	v.f.s.l.				
19	400	25	Hadley	v.f.s.l.				
20	300	10	Hadley	l.f.s.	Low Bottom			
	36,770							
	7.0 miles							

SCS 347 5-57
Tabular Computations

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

TABLE 2 - CONNECTICUT RIVER BANK EROSION STUDY

SULLIVAN COUNTY, NEW HAMPSHIRE

Location	Slope of Bank	Length of Bank	Average Height of Bank	Approximate Depth of Bank Lost Per Year		Approximate Volume Per Year Lost		Approximate Area Lost Per Year		Soil Type	Soil Description
				From	To	From	To	From	To		
		Ft	Ft	Ft	Ft	C.Y.	C.Y.	Ac	Ac		
21	Vertical	3,900	7	3	5	3,030	5,060	0.27	0.45	Hadley & Winooski	v.f.s.l.
22	Vertical	3,300	10	3	5	3,670	6,110	0.23	0.38	Hadley	v.f.s.l.
23	Vertical	1,900	4	3	5	840	1,410	0.13	0.22	Hadley	v.f.s.l.
		4,700	18	5	7	15,670	21,930	0.54	0.76	Hadley	v.f.s.l.
		6,600				16,510	23,340	0.67	0.98		
24	Vertical	4,000	4	2	4	1,190	2,370	0.18	0.37	Hadley	v.f.s.l.
25	Vertical	1,300	40	1	3	1,925	5,780	0.03	0.09	Hadley & Agawam	v.f.s.l.
		2,600	15	3	5	4,330	7,220	0.16	0.30	Hadley & Agawam	v.f.s.l.
		900	20	1	3	670	2,000	0.02	0.06	Hadley & Agawam	v.f.s.l.
		4,800				6,925	15,000	0.23	0.45		
26	Vertical	2,400	20	2	4	3,560	7,110	0.11	0.22	Hadley	v.f.s.l.
		3,000	15	2	4	3,330	6,670	0.14	0.28	Hadley	v.f.s.l.
		5,400				6,890	13,780	0.27	0.50		
27	Vertical	1,700	20	1	3	1,260	3,780	0.04	0.12	Hadley	v.f.s.l.
		1,800	20	3	5	4,000	6,670	0.12	0.21	Hadley	v.f.s.l.
		2,200	15	1	2	1,330	2,660	0.05	0.10	Hadley	v.f.s.l.
		5,700				6,590	13,110	0.21	0.43		
28	Vertical	3,000	8	1	3	890	2,670	0.07	0.21	Hadley	v.f.s.l.
		1,100	18	3	5	2,200	3,670	0.21	0.34	Hadley	v.f.s.l.
		4,100				3,090	6,340	0.28	0.55		

TABLE 2

SCS-347 5-57
Tabular Computations

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

TABLE 2 – CONNECTICUT RIVER BANK EROSION STUDY

SULLIVAN COUNTY, NEW HAMPSHIRE

Location	Slope of Bank	Length of Bank Ft	Average Height of Bank Ft	Approximate Depth of Bank Lost Per Year From Ft	To Ft	Approximate Volume Lost Per Year From C.Y.	To C.Y.	Approximate Area Lost Per Year From Ac	To Ac	Soil Type	Soil Description
29	Vertical	1,600	20	1	2	1,185	2,370	0.04	0.07	Hadley	v.f.s.l.
30	Sloping	1,300						0.04	0.15	Hadley	v.f.s.l.
31	Vertical	2,000	50	1	2	3,705	7,410	0.05	0.09	Hadley	v.f.s.l.
32	Sloping	1,500		VERY MINOR EROSION						Hadley	v.f.s.l.
33	Sloping	2,500		VERY MINOR EROSION						Hadley, Winooski & Limerick	v.f.s.l. s.l.
34	Vertical	3,300	10	1	2	1,220	2,445	0.08	0.15	Hadley	v.f.s.l.
35	Vertical	2,000	15	1	2	1,110	2,220	0.05	0.10	Hadley	v.f.s.l.
36	Sloping	3,300						0.04	0.08	Hadley	v.f.s.l.
37	Sloping	1,300		VERY MINOR EROSION						Hadley	v.f.s.l.
38	Sloping	1,000		VERY MINOR EROSION						Hadley	v.f.s.l.
39	Sloping	1,800		VERY MINOR EROSION						Hadley	v.f.s.l.

			Volume From C.Y.	Volume To C.Y.	Area From Ac	Area To Ac
Total length of Sloping Bank	12,700 Ft					
Total length of Vertical Bank	46,700 Ft					
Total length of Bank Studied	59,400 Ft					
Total length of sloping Bank with significant Erosion	4,600 Ft	Totals lost from Sloping Banks with significant Erosion	—	—	0.08	0.23
Total length of vertical bank with significant Erosion	46,700 Ft	Totals lost from Vertical Banks with significant Erosion	55,115	99,555	2.56	4.52
Total length of Bank with significant Erosion	51,300 Ft	Totals lost from banks with significant Erosion			2.64	4.75

TABLE 2

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

TABLE 3

CONNECTICUT RIVER BANK EROSION STUDY

GRAFTON COUNTY, NEW HAMPSHIRE

Location No.	Length of eroded Bank Ft.	Average Height of Eroded Bank Ft.	Soil Type	Soil Description			
40-46	1800	25	40-42 Hartland 43-46 Windsor	V.F.S.L. L.S.			
47, 49, 50	1800	19	Windsor	L.S.			
48	100	42	Windsor	L.S.			
51	1800	19	Windsor	L.S.			
52	2600	12	Hadley	V.F.L.S.			
53	1,000	8	Hartland	V.F.L.S.			
54	500	5	Hadley	V.F.L.S.			
55-57	3,000	8	Hadley & Suncook & Colton	V.F.L.S. & L.S. & G.L.S.			
58	300	6	Windsor	L.S.			
59-60	3,500	6	Hadley & Suncook	V.F.L.S. L.S.			
61	600	9	Hadley	V.F.L.S.			
62	1,500	25	Hadley	V.F.L.S.			
63, 64	900	18	Agawam	V.F.L.S.			
65	1,500	5	Hadley	V.F.L.S.			

☆ U.S. GOVERNMENT PRINTING OFFICE: 1971—O-416-224

TABLE 3

CONNECTICUT RIVER BANK EROSION STUDY

GRAFTON COUNTY, NEW HAMPSHIRE

Location No.	Length of Eroded Bank Ft.	Average Height of Eroded Bank Ft.	Soil	Type	Soil Description			
66	100	20	Hadley		V.F.S.L.			
67	4,800	14	Hadley		V.F.S.L.			
68	2,500	14	Hadley		V.F.S.L.			
69	1,400	8	Hadley		V.F.S.L.			
70	2 GULLIES ON UNDERHILL FARM		Hadley		V.F.S.L.			
71	2,500	10	Suncook & Hadley		L.S. & V.F.S.L.			
72	400	7	Suncook		S.L.			
73	1,000	10	Hadley		V.F.S.L.			
74	1,700	10	Hadley		V.F.S.L.			
75	2,500	15	Hadley		V.F.S.L.			
76	2,500	25	Hadley		V.F.S.L.			
77	500	10	Hadley		V.F.S.L.			
78	800	10	Hadley		V.F.S.L.			
79	2,200	21	Suncook & Hadley		S.L. & V.F.S.L.			

TABLE 3

CONNECTICUT RIVER BANK EROSION STUDY

GRAFTON COUNTY, NEW HAMPSHIRE

Location No.	Length of Eroded Bank Ft.	Average Height of Eroded Bank Ft.	Soil	Type	Soil Description			
80	100	14	Hadley		V.F.S.L.			
81	1,500	10	Hadley		V.F.S.L.			
82	400	18	Mixed Alluvial Land					
83	1,500	18	Hadley		V.F.S.L			
84	800	22	Hadley and Winooski		V.F.S.L.			
85	Two Gullies 15 Feet Deep		Hadley		V.F.S.L.			
86	800	18	Hadley		V.F.S.L.			
87	2,500	18	Hadley		V.F.S.L			
88	1,700	12	Hadley		V.F.S.L			
89	600	18	Hadley		V.F.S.L.			
TOTAL	53,700	or 10.2 miles						

U.S. GOVERNMENT PRINTING OFFICE 1971 - O-416 274

SCS-347 5-57
Tabular Computations

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

TABLE 4 – CONNECTICUT RIVER BANK EROSION STUDY

WINDSOR COUNTY, VERMONT

Location	Length of Eroded Bank Ft	Average Height of Eroded Bank Ft	Approximate Depth of Bank Lost Per Year From Ft	To Ft	Approximate Volume lost Per Year From C.Y.	To C.Y.	Approximate Area Lost Per Year From Ac	To Ac	Soil Type	Soil Description
91	3960	2.5	2	3	735	1100	0.18	0.27	Hadley	v.f.s.l.
92	2640	2.5	2	3	490	735	0.12	0.18	Windsor	l.s.
93	1980	7.5	2	3	1100	1650	0.09	0.14	Windsor	l.s.
94	660	12.5	2	3	610	915	0.03	0.05	Windsor	l.s.
	9240				2935	4400	0.42	0.64		
95	6600	2.5	2	3	1220	1835	0.30	0.45	Windsor	l.s.
96	1320	7.5	2	3	735	1100	0.06	0.09	Hadley & Winooski	v.f.s.l.
97	3960	7.5	2	3	2200	3300	0.18	0.27	Ondawa	s.l.
98	1320	7.5	2	3	735	1100	0.06	0.09	Unadilla (Hartland)	G.l.
99	1320	7.5	2	3	735	1100	0.06	0.09	Windsor	l.s.
100	3300	12.5	2	3	3055	4585	0.15	0.23	Windsor	l.s.
101	2640	17.5	2	3	3420	5135	0.12	0.18	Hadley	v.f.s.l.
102	1320	25	2	3	2445	3665	0.06	0.09	Windsor	l.s.
	21,780				14,545	21,820	0.99	1.49		
103	3300	2.5	2	3	610	915	0.15	0.23	Hadley	v.f.s.l.
104	2640	2.5	2	3	490	735	0.12	0.18	Hadley	v.f.s.l.
105	2640	2.5	2	3	490	735	0.12	0.18	Winooski	v.f.s.l.
106	3960	2.5	2	3	735	1100	0.18	0.27	Made Land	
107	1320	7.5	2	3	735	1100	0.06	0.09	Podunk	f.s.l.
	13,860				3060	4585	0.63	0.95		

TABLE 4

SCS-347 5-57
Tabular Computations

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

TABLE 4 – CONNECTICUT RIVER BANK EROSION STUDY

WINDSOR COUNTY, VERMONT

Location No.	Length of Eroded Bank	Average Height of Eroded Bank	Approximate depth of bank lost per year		Approximate Volume lost per year		Approximate Area lost per year		Soil Type	Soil Description
			From	To	From	To	From	To		
	Ft	Ft	Ft	Ft	Cy.	Cy.	Ac.	Ac.		
108	1980	2.5	2	3	365	550	0.09	0.14	Windsor	L.S.
109	1980	2.5	2	3	365	550	0.09	0.14	Ondawa	S.L.
110	1320	2.5	2	3	245	365	0.06	0.09	Windsor	L.S.
111	1320	7.5	2	3	735	1100	0.06	0.09	Windsor	L.S.
112	1320	7.5	2	3	735	1100	0.06	0.09	Podunk	F.S.L.
113	1320	12.5	2	3	1220	1835	0.06	0.09	Windsor	L.F.S.
114	1320	12.5	2	3	1220	1835	0.06	0.09	Windsor	L.F.S.
115	1980	17.5	2	3	2565	3850	0.09	0.14	Windsor	L.F.S.
116	1320	2.5	2	3	2445	3665	0.06	0.09	Windsor	L.S.
	13,860				9895	14,850	0.63	0.96		
117	1320	2.5	2	3	245	365	0.06	0.09	Hadley	V.F.S.L.
118	3960	2.5	2	3	735	1100	0.18	0.27	Windsor	L.F.S.
119	660	7.5	2	3	365	550	0.03	0.05	Windsor	L.F.S.
120	660	7.5	2	3	365	550	0.03	0.05	Windsor	L.F.S.
121	660	7.5	2	3	365	550	0.03	0.05	Windsor	L.F.S.
122	660	12.5	2	3	610	915	0.03	0.05	Windsor	L.F.S.
123	2460	17.5	2	3	3420	5135	0.12	0.18	Windsor	L.F.S.
	10,560				6095	9165	0.48	0.74		
124	2460	2.5	2	3	490	735	0.12	0.18	Windsor	L.F.S.
125	3300	7.5	2	3	1830	2750	0.15	0.23	Windsor	L.F.S.
126	660	12.5	2	3	610	915	0.03	0.05	Windsor	L.F.S.
	6600				2930	4400	0.30	0.46		
TOTAL	75,900				39,460	59,220	3.45	5.24		
	14.38 MILES									

TABLE 4

SCS-347 5-57
Tabular Computations

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

TABLE 5 - CONNECTICUT RIVER BANK EROSION STUDY

ORANGE COUNTY, VERMONT

Location	Length of Eroded Bank Ft	Average Height of Eroded Bank Ft	Approximate Depth of Bank Lost Per Year Ft	Approximate Volume Lost Per Year C.Y.	Approximate Area Lost Per Year From Ac	To Ac	Soil Type	Soil Description					
127	500	10	4.3	805	0.05	0.25	Agawam	v.f.s.l.					
128	700	15	6.22	2420	0.1	0.5	Hadley	v.f.s.l.					
129	1000	15	2.18	1210	0.05	0.25	Agawam	v.f.s.l.					
130	100	10	8.71	325	0.02	0.10	Hadley	v.f.s.l.					
131	1600	10	4.08	2420	0.15	0.75	Hadley	v.f.s.l.					
132	600	10	7.26	1615	0.10	0.5	Hadley	v.f.s.l.					
133	750	15	11.62	4840	0.20	1.00	Hadley	v.f.s.l.					
134	600	10	3.63	805	0.05	0.25	Hadley	v.f.s.l.					
135	600	10	3.63	805	0.05	0.25	Hadley	v.f.s.l.					
136	1000	10	4.36	1615	0.10	0.50	Hadley	v.f.s.l.					
137	1000	15	4.36	2420	0.10	0.5	Hadley	v.f.s.l.					
138	2500	10	3.48	3225	0.2	1.00	Hadley	v.f.s.l.					
139	2500	10	3.48	3225	0.2	1.00	Hadley	v.f.s.l.					
140	200	5	4.36	160	0.02	0.1	Hadley	v.f.s.l.					
141	1000	25	4.36	4035	0.10	0.5	AGAWAM	v.f.s.l.					
142	800	15	5.44	2420	0.10	0.5	Hadley	v.f.s.l.					

TABLE 5

SCS 347 5-57
Tabular Computations

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

TABLE 5 - CONNECTICUT RIVER BANK EROSION STUDY

ORANGE COUNTY, VERMONT

Location	Length of Eroded Bank Ft	Average Height of Eroded Bank Ft	Approximate Depth of Bank Lost Per Year Ft	Approximate Volume Lost Per Year C.Y.	Approximate Area Lost Per Year From Ac	To Ac	Soil Type	Soil Description
143	2400	15	7.26	9680	0.4	2.0	Hadley	v.f.s.l.
144	2400	15	7.26	9680	0.4	2.0	Hadley	v.f.s.l.
145	800	15	10.89	4840	0.2	1	Hadley	v.f.s.l.
146	400	15	5.44	1210	0.05	0.25	Hadley	v.f.s.l.
147	1400	15	12.45	9680	0.4	2.0	Hadley	v.f.s.l.
148	100	10	8.71	325	0.02	0.1	Hadley	v.f.s.l.
149	1400	15	12.45	9680	0.4	2.0	Hadley	v.f.s.l.
150	1500	15	2.90	2420	0.1	0.5	Hadley	v.f.s.l.
151	200	20	10.89	1615	0.05	0.25	Hadley	v.f.s.l.
152	400	25	10.89	4035	0.1	0.5	Hadley	v.f.s.l.
153	900	10	4.84	2420	0.1	0.5	Hadley	v.f.s.l.
154	300	15	7.26	805	0.05	0.25	Hadley	v.f.s.l.

TABLE 5

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

BRATTLEBORO QUADRANGLE
VERMONT—NEW HAMPSHIRE
15 MINUTE SERIES (TOPOGRAPHIC)

Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography from aerial photographs by multiplex methods
Aerial photographs taken 1951. Field check 1953 and 1954

Polyconic projection. 1927 North American datum
10,000-foot grids based on Vermont and New Hampshire coordinate systems

Red tint indicates area in which only landmark buildings are shown

Unchecked elevations are shown in brown

1000-meter Universal Transverse Mercator grid ticks, zone 18, shown in blue

14½°
MAGNETIC NORTH
TRUE NORTH
APPROXIMATE MEAN DECLINATION, 1954

SCALE 1:62500

1 ½ 0 1 2 3 4 MILES

3000 0 3000 6000 9000 12000 15000 18000 21000 FEET

1 .5 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY WASHINGTON 25, D. C
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

VT.
QUADRANGLE LOCATION

ROAD CLASSIFICATION

Heavy-duty — Light-duty
Medium-duty — Unimproved dirt
U. S. Route — State Route

BRATTLEBORO, VT.—N. H.
N4245—W7230/15

1954

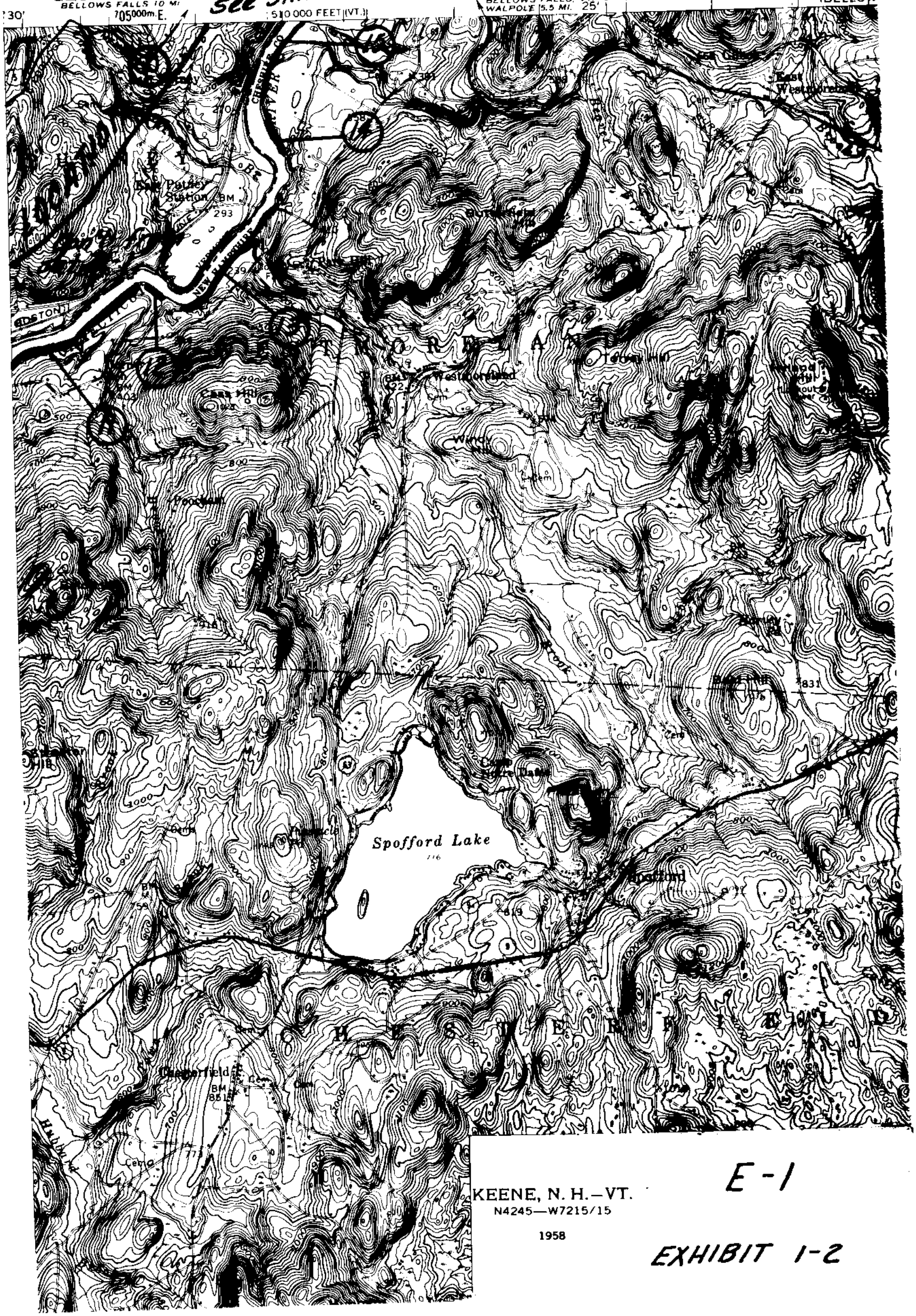
D-1

EXHIBIT 1-1

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF NEW HAMPSHIRE
HIGHWAY DEPARTMENT

See sht. E-2



KEENE, N. H.–VT.
N4245—W7215/15
1958

E-1

EXHIBIT 1-2

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF VERMONT
CHARLES G. DOLL
STATE GEOLOGIST

STATE OF NEW HAMPSHIRE
HIGHWAY DEPARTMENT

BELLOWS FALLS QUADRANGLE
NEW HAMPSHIRE—VERMONT
15 MINUTE SERIES (TOPOGRAPHIC)

Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Culture and drainage in part compiled from aerial photographs
Topography by planetable surveys 1927. Revised 1957

Polyconic projection. 1927 North American datum
10,000-foot grids based on New Hampshire and Vermont coordinate systems
1000-meter Universal Transverse Mercator grid ticks, zone 18, shown in blue

Area covered by dashed light-blue pattern is subject to controlled inundation to 550 feet

UTM GRID AND 1957 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:62500

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

ROAD CLASSIFICATION

Heavy-duty — Light-duty
Medium-duty — Unimproved dirt
U. S. Route — State Route

QUADRANGLE LOCATION

E-2

BELLOWS FALLS, N. H.—VT.
N4300—W7215/15

1957

AMS 6570 III—SERIES V712

EXHIBIT 1-3

FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON, D. C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF VERMONT
CHARLES G. DOLL
STATE GEOLOGIST

STATE OF NEW HAMPSHIRE
HIGHWAY DEPARTMENT

CLAREMONT QUADRANGLE
NEW HAMPSHIRE–VERMONT
15 MINUTE SERIES (TOPOGRAPHIC)

Mapped, edited, and published by the Geological Survey

Control by USGS, USC&GS, and Vermont-New Hampshire Boundary Commission

Culture and drainage in part compiled from aerial photographs
Topography by planetable surveys 1926. Culture revised 1957

Polyconic projection. 1927 North American datum
10,000-foot grids based on New Hampshire coordinate system and Vermont coordinate system
1000-meter Universal Transverse Mercator grid ticks, zone 18, shown in blue

Area covered by dashed light-blue pattern is subject to controlled inundation to 545 feet

Red tint indicates areas in which only landmark buildings are shown

UTM GRID AND 1957 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:62500

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON 25, D. C.,
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

ROAD CLASSIFICATION
Heavy-duty — Light-duty
Medium-duty — Unimproved dirt
U. S. Route — State Route

QUADRANGLE LOCATION

CLAREMONT, N. H.–VT.
N4315—W7215/15
1957
AMS 6570 IV—SERIES V712

E-3

EXHIBIT 1-4

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

VERMONT–NEW HAMPSHIRE
HANOVER QUADRANGLE

H.M.Wilson, Geographer.
J.H.Jennings, in charge of section.
Topography by Chas. Hartmann, Jr., and L.C.Fletcher.
Control by Coast and Geodetic Survey and W.Carvel Hall.
Surveyed in 1905-1906.

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1906.

SCALE 1:62500

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1962
MR 2023

Polyconic projection. 1927 North American datum

This area also covered by 7.5 minute
1:24 000 scale maps: Hanover, Quechee,
Hartland and North Hartland, surveyed 1959

HANOVER, VT.–N. H.
N4330—W7215/15
1906

E-4

FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON 25, D. C.
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

EXHIBIT 1-5

See Sht. F-5 Con't from E-4

BRADFORD 19 MI.
EAST THETFORD 5 MI.

UNITED STATES — WOODSVILLE 34 MI. LYME 5 MI.

DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

STATE OF NEW HAMPSHIRE

HIGHWAY DEPARTMENT

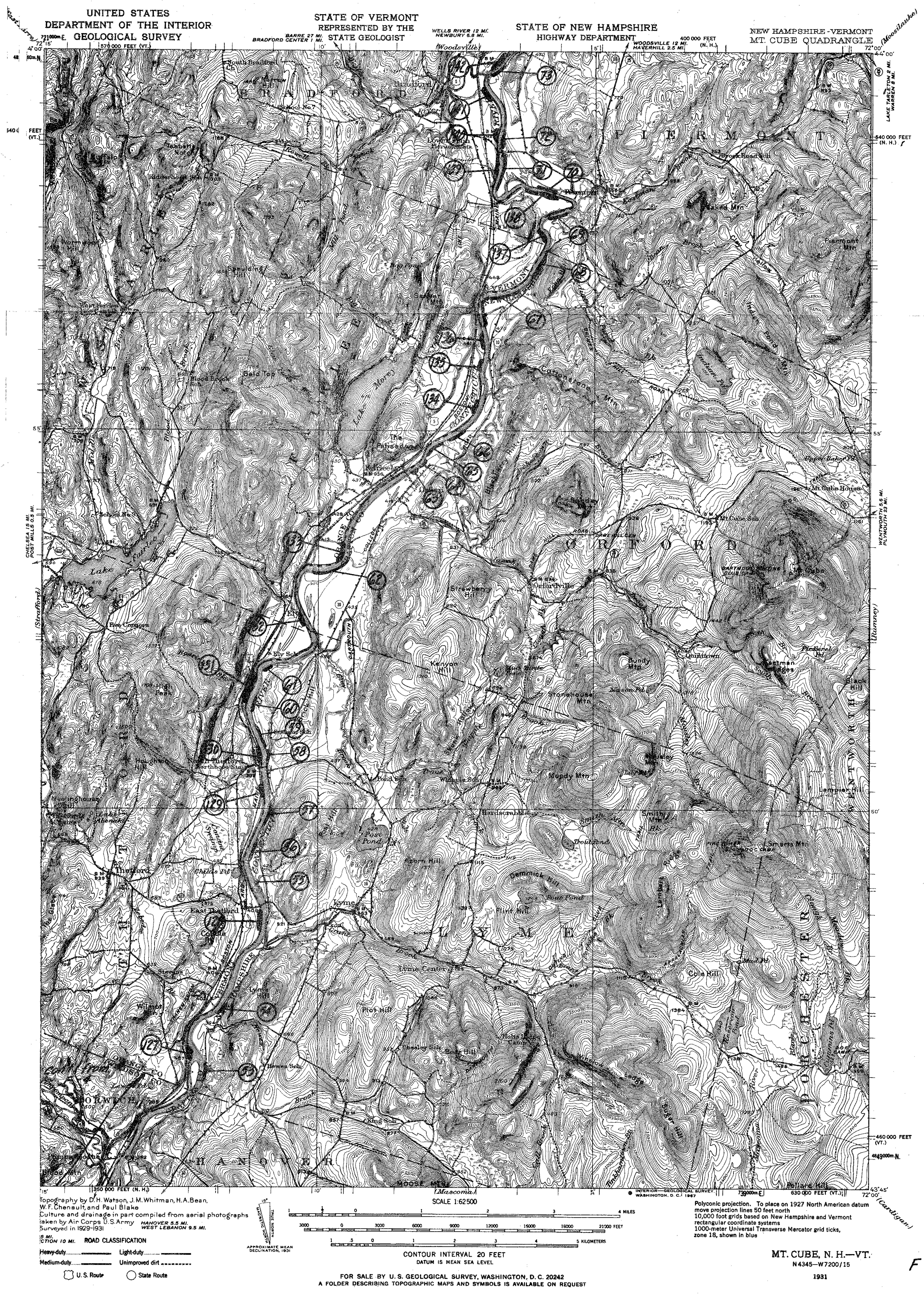
MASCOMA, N.H.-VT.

N4330—W7200/15

1927

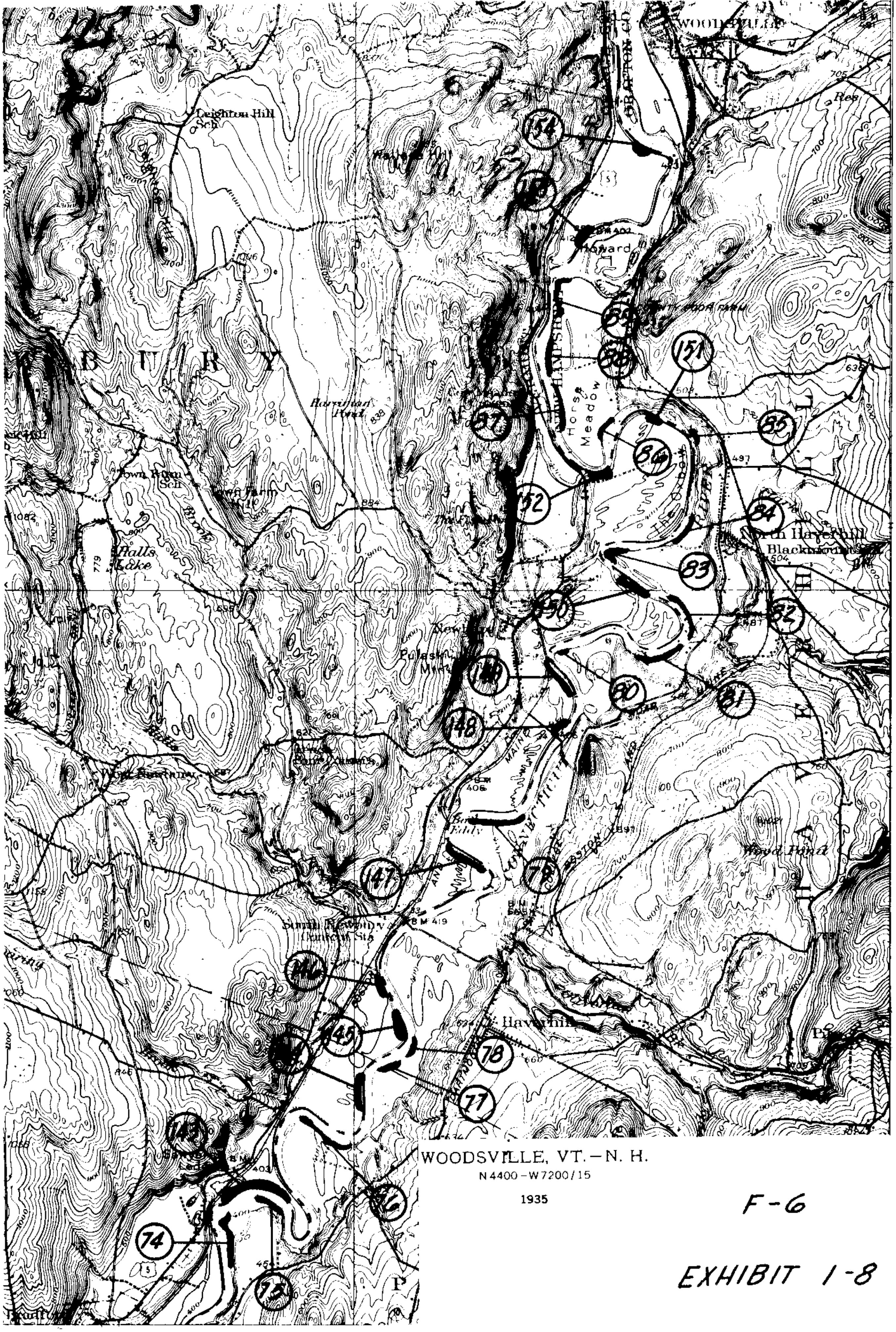
F-4

EXHIBIT 1-6



F-5

EXHIBIT 1-7



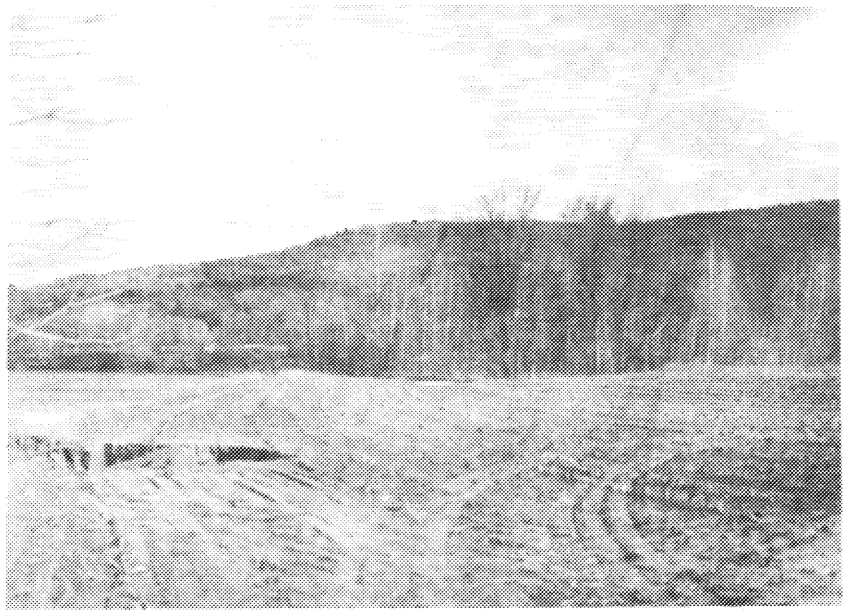
WOODSVILLE, VT. – N. H.

N 4400 – W 7200/15

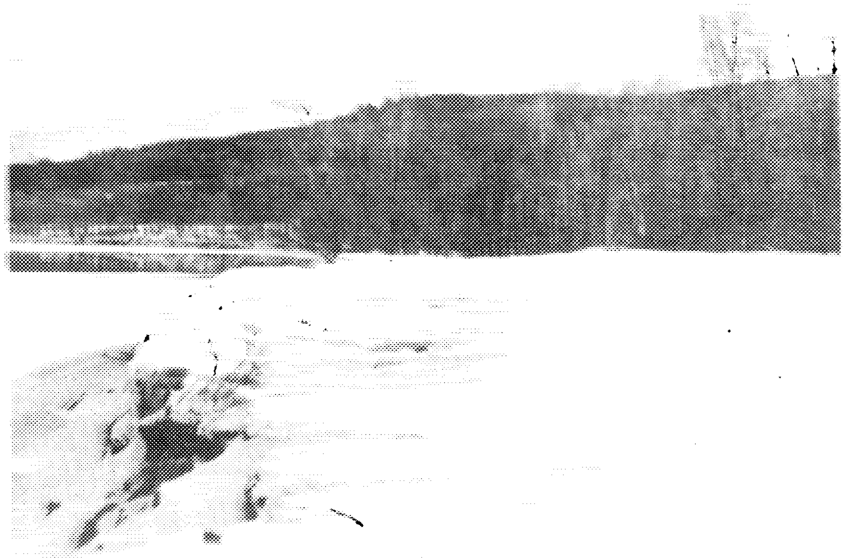
1935

F-6

EXHIBIT 1-8



1957

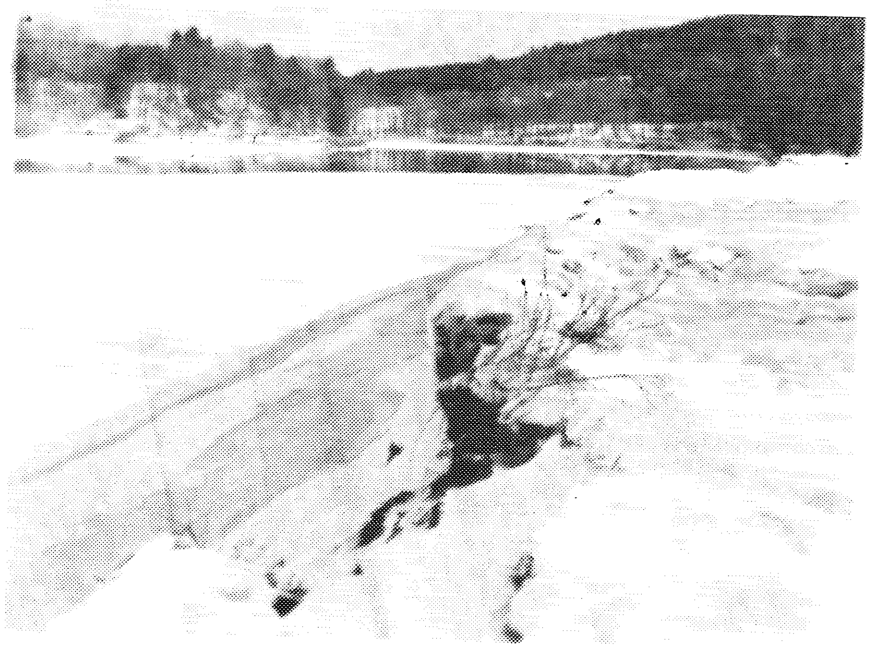


2/13/74

LOCATION 12
CHESHIRE COUNTY FARM
WESTMORELAND, NEW HAMPSHIRE

EXHIBIT 2-1

LOCATION 12
CHESHIRE COUNTY FARM
WESTMORELAND, NEW HAMPSHIRE



2/13/74

EXHIBIT 2-1

SOIL SURVEY INTERPRETATIONS

SOIL: Agawam very fine sandy loam
MAP SYMBOL(S): 24
BRIEF SOIL DESCRIPTION:

STATE: New Hampshire
DATE: 7-73
MLRA(S): 143, 144

These are well-drained soils that formed in thick deposits of sands. Typically they have a very dark greyish-brown very fine sandy loam surface soil 10 inches thick. The subsoil is yellowish-brown fine sandy loam 15 inches thick. The underlying material to a depth of 42 inches is light olive brown loamy fine sand and olive fine sand. These soils are mainly on outwash plains and stream terraces. Slopes range from 0 to 15 percent.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING

Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No.			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHO	4	10	200				
0-15	vfsl, fsl	SM, ML	A-4	95-100	90-100	45-65	2.0-6.0	.13-.25	5.0-6.5	Low
15-25	fsl, vfsl	SM, ML	A-4	95-100	90-100	40-55	2.0-6.0	.11-2.0	5.0-6.0	Low
25-42	lfs, fs, s	SM SP-SM	A-2	90-100	85-100	10-35	6.0	.02-.11	5.0-6.0	Very Low

Depth to Bedrock (Ft): 6-8+
Depth to Fragipan (Ft): ——
Depth to Seasonal High Water Table (Ft): [illegible]
Flood Hazard: None
Potential Frost Action: Low
Hydrologic Group: B

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Good
Sand	Poor 1/ excess fines
Gravel	Poor: excess fines
Roadfill	Fair: excess fines
Daily Cover For Landfill	Good

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES

Highway Location	Cut slopes unstable, erodible
Pond Reservoir Areas	Moderately rapid permeability
Pond Embankments	Moderate permeability, subject to piping, erodible
Sprinkler Irrigation	High available water capacity
Drainage	2/
Diversions and Waterways	Moderately rapid permeability, high available water capacity, erodible

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	A & B C	Slight Moderate	 Slope
Sewage Lagoon	A & B C	Severe Severe	Moderately rapid permeability Moderately rapid permeability, slope
Dwellings (With Basements)	A & B C	Slight Moderate	 Slope
Dwellings (Without Basements)	A & B C	Slight Moderate	 Slope
Lawns and Landscaping	A & B C	Slight Moderate	 Slope
Local Roads, Streets and Parking Lots	A B C	Slight Moderate Severe	 Slope Slope
Shallow Excavations (6 feet or less)	A & B C	Slight Moderate	 Slope

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1/ Fair below about 2 feet

2/ Practice generally not applied

EXHIBIT 3-1

Agawam very fine sandy loam

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Camp Areas (Tent and Camp Trailers)	A & B C	Slight Moderate	 Slope
Picnic Areas (Park-Type)	A & B C	Slight Moderate	 Slope
Playgrounds (Athletic Fields)	A B C	Slight Moderate Severe	 Slope Slope
Paths and Trails (Hiking and Bridle)	A, B & C	Slight	

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE			
Use	Slope	Suitablity	Major Soil Feature(s) Affecting Use
Truck Crops	A & B C	Good Fair	 Slope
Field Crops	A & B C	Good Fair	 Slope
Hay and Pasture Crops	A, B & C	Good	
Apple Orchards	NOT RATED		

SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT

Slope	Degree of Limitation Related to – – –						Productivity			Species to Favor – –	
	Seedling Mortality	Plant Competition: Hardwood	Plant Competition: Conifer	Windthrow Hazard	Erosion Hazard	Equipment Restric-tions	Suit-ability Group	Major Species	Site Index Range	Existing Stands	For Planting
All	Slight	Slight	Moderate	Slight	Slight	Slight	402	White Pine* Red Oak Red Pine Northern Hardwoods	60-70 55-65 60-70 52-59	W.P. R.O. R.P. W.A. S.M.	W.P. R.P. W.S.

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE			
Kinds of Wildlife	Slope	Suitability	Major Soil Feature(s) Affecting Use
Openland	All	Good	
Woodland	All	Good	
Wetland	All	Very Poor	No water

* Indicator Species

SOIL SURVEY INTERPRETATIONS

SOIL Colton gravelly loamy sand
MAP SYMBOL(S): 622
BRIEF SOIL DESCRIPTION

STATE: New Hampshire
DATE: 7-73
MLRA(S): 143, 144

These are excessively drained soils that formed in thick sand and gravel deposits. Typically these soils have a very dark grayish-brown gravelly loamy sand surface layer 7 inches thick over a gray leached gravelly loamy sand layer about an inch thick. The subsoil to 16 inches is dark reddish-brown and reddish-brown gravelly loamy sand. Below this to 50 inches is yellowish-brown and pale brown very gravelly snad. These soils generally occupy kames, eskers, and terrace breaks. Slopes range from 15 to more than 35 percent.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING

Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No.			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHO	4	10	200				
0-16	gls	SM, SP-SM	A-1 A-2	65-75	55-70	10-30	>6.0	.05-.08	5.0	Very Low
16-50	vgs, vgcos, gcos	SP, SP-SM GP, GP-GM	A-1	35-55	25-50	0-10	>6.0	.01-.05	4.5-6.0	Very Low

Depth to Bedrock (Ft): 6-8+
Depth to Fragipan (Ft): ——
Depth to Seasonal High Water Table (Ft): 5+
Flood Hazard: None
Potential Frost Action: Low
Hydrologic Group: A

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Poor: coarse fragments
Sand	Good
Gravel	Good
Roadfill	Good
Daily Cover For Landfill	Poor: coarse fragments, slope

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES

Highway Location	Cut slopes unstable, slope
Pond Reservoir Areas	Rapid permeability, slope
Pond Embankments	Rapid permeability, slope
Sprinkler Irrigation	Very low available water capacity, slope
Drainage	1/
Diversions and Waterways	Rapid permeability, very low available water capacity, slope

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe 2/	Slope
Sewage Lagoon	All	Severe 2/	Rapid permeability, slope
Dwellings (With Basements)	All	Severe	Slope
Dwellings (Without Basements)	All	Severe	Slope
Lawns and Landscaping	All	Severe	Sandy and gravelly, slope
Local Roads, Streets and Parking Lots	All	Severe	Slope
Shallow Excavations (6 feet or less)	All	Severe	Poor sidewall stability, slope

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1/ Practice generally not applied.

2/ Potential pollution hazard to nearby wells, streams and lakes.

EXHIBIT 3-2

Colton gravelly loamy sand

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Camp Areas (Tent and Camp Trailers)	All	Severe	Slope
Picnic Areas (Park-Type)	All	Severe	Slope
Playgrounds (Athletic Fields)	All	Severe	Slope
Paths and Trails (Hiking and Bridle)	All	Severe	Slope

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE			
Use	Slope	Suitablity	Major Soil Feature(s) Affecting Use
Truck Crops	All	Unsuited	Droughty, slope
Field Crops	All	Unsuited	Droughty, slope
Hay and Pasture Crops	All	Unsuited	Droughty, slope
Apple Orchards	All	Unsuited	Droughty, slope

SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT

Slope	Degree of Limitation Related to – – –						Productivity			Species to Favor – –	
	Seedling Mortality	Plant Competition: Hardwood	Plant Competition: Conifer	Windthrow Hazard	Erosion Hazard	Equipment Restric-tions	Suit-ability Group	Major Species	Site Index Range	Existing Stands	For Planting
D & E	Moderate	Slight	Slight	Slight	Slight	Slight	4s1	White Pine*	60-70	W.P.	W.P.
								Red Pine	60-70	R.P.	R.P.
								Red Spruce	30-40	R.S.	
								Northern Hardwood	52-59	S.M	
										Y.B	
F	Moderate	Slight	Slight	Slight	Moderate	Severe	4s1				

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE			
Kinds of Wildlife	Slope	Suitability	Major Soil Feature(s) Affecting Use
Openland	All	Poor	Droughty, slope
Woodland	All	Poor	Droughty, slope
Wetland	All	Very Poor	No water, slope

*Indicator Species

SOIL SURVEY INTERPRETATIONS

SOIL: Hadley very fine sandy loam, frequently flooded or low bottom phase
STATE: New Hampshire
MAP SYMBOL(S): 8
DATE: 7-73
BRIEF SOIL DESCRIPTION
MLRA(S): 144

These are well-drained soils that formed in floodwater deposits consisting mainly of very fine sands and silt. Typically these soils have a very dark grayish-brown very fine sandy loam surface layer 10 inches thick. The underlying material to 40 inches is dark grayish-brown and olive silt loam. Below this the texture is variable ranging from very fine sandy loam to sand and gravel. Slopes range from 0 to 3 percent. These soils are subject to flooding from adjacent streams at least once in 5 years.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING

Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No.			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHO	4	10	200				
0-10	vfsl, sil	ML	A-4	100	100	60-85	0.6-2.0	.15-.30	4.5-7.3	Low
10-40	sil, vfsl	ML	A-4	100	100	55-80	0.6-2.0	.13-.26	5.6-7.3	Low
40-72	Variable textures ranging from very fine sandy loam to sand and gravel									

Depth to Bedrock (Ft): 5+
Depth to Fragipan (Ft): ——
Depth to Seasonal High Water Table (Ft): 4-6+
Flood Hazard: Severe
Potential Frost Action: High
Hydrologic Group: B

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Good
Sand	Poor: excess fines
Gravel	Poor: excess fines
Roadfill	Fair: high potential frost action
Cover For Landfill	Good

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES

Highway Location	Subject to frequent flooding, high potential frost action
Pond Reservoir Areas	Subject to frequent flooding, moderate permeability
Pond Embankments	Moderate slow permeability, subject to piping, erodible
Sprinkler Irrigation	High available water capacity, moderate intake rate
Drainage	Frequent flooding, well-drained
Diversions and Waterways	1/

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Subject to frequent flooding
Sewage Lagoon	All	Severe	Subject to frequent flooding
Dwellings (With Basements)	All	Severe	Subject to frequent flooding
Dwellings (Without Basements)	All	Severe	Subject to frequent flooding, high potential frost action
Lawns and Landscaping	All	Severe	Subject to frequent flooding
Local Roads Streets and Parking Lots	All	Severe	Subject to frequent flooding, high potential frost action
Shallow Excavations (6 feet or less)	All	Severe	Subject to frequent flooding

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1/ Practice generally not applied.

EXHIBIT 3-3

Hadley very fine sandy loam, frequently flooded or low bottom phase

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Camp Areas (Tent and Camp Trailers)	All	Severe	Subject to frequent flooding
Picnic Areas (Park-Type)	All	Moderate	Subject to frequent flooding
Playgrounds (Athletic Fields)	All	Severe	Subject to frequent flooding
Paths and Trails (Hiking and Bridle)	All	Moderate	Subject to frequent flooding

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE			
Use	Slope	Suitablity	Major Soil Feature(s) Affecting Use
Truck Crops	All	Fair	Subject to frequent flooding
Field Crops	All	Fair	Subject to frequent flooding
Hay and Pasture Crops	All	Good	
Apple Orchards	Not rated		

SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT

Slope	Degree of Limitation Related to – – –						Productivity			Species to Favor – –	
	Seedling Mortality	Plant Competition: Hardwood	Plant Competition: Conifer	Windthrow Hazard	Erosion Hazard	Equipment Restric-tions	Suit-ability Group	Major Species	Site Index Range	Existing Stands	For Planting
All	Slight	Slight	Moderate	Slight	Slight	Slight	3o1	White Pine* Red Pine Northern Hardwoods	70-80 70-80 59-66	W.P. S.M. Y.B.	W.P. R.P. W.S.

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE			
Kinds of Wildlife	Slope	Suitability	Major Soil Feature(s) Affecting Use
Openland	All	Fair	Subject to frequent flooding
Woodland	All	Good	
Wetland	All	Very Poor	Deep to water table

* Indicator Species

USDA SCS HYATTSVILLE MD 1973

SOIL SURVEY INTERPRETATIONS

SOIL: Hadley very fine sandy loam, occasionally flooded or high bottom phase
MAP SYMBOL(S): 8H
BRIEF SOIL DESCRIPTION

STATE: New Hampshire
DATE: 7-73
MLRA(S): 144

These are well-drained soils that formed in floodwater deposits consisting mainly of very fine sands and silt. Typically these soils have a very dark grayish-brown very fine sandy loam surface layer about 10 inches thick. The underlying material to 40 inches is dark grayish-brown and olive silt loam. Below this the texture is variable ranging from very fine sandy loam to sand and gravel. Slopes range from 0 to 3 percent. These soils are subject to flooding from adjacent streams at least once in 5 to 10 years.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING

Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No.			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHO	4	10	200				
0-10	vfsl, sil	ML	A-4	100	100	60-85	0.6-2.0	.15-.30	4.5-7.3	Low
10-40	sil, vfsl	ML	A-4	100	100	55-80	0.6-2.0	.13-.28	5.6-7.3	Low
40-72	Variable textures ranging from very fine sandy loam to sand and gravel									

Depth to Bedrock (Ft): 5+
Depth to Fragipan (Ft): ——
Depth to Seasonal High Water Table (Ft): 4-6+
Flood Hazard: Moderate
Potential Frost Action: High
Hydrologic Group: B

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Good
Sand	Poor: excess fines
Gravel	Poor: excess fines
Roadfill	Fair: high potential frost action
Daily Cover For Landfill	Good

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES

Highway Location	Subject to occasional flooding, high potential frost action
Pond Reservoir Areas	Subject to occasional flooding, moderate permeability
Pond Embankments	Moderately slow permeability, subject to piping, erodible
Sprinkler Irrigation	High available water capacity, moderate intake rate
Drainage	Occasional flooding, well-drained
Diversions and Waterways	1/

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Subject to occasional flooding
Sewage Lagoon	All	Severe	Subject to occasional flooding
Dwellings (With Basements)	All	Severe	Subject to occasional flooding
Dwellings (Without Basements)	All	Severe	Subject to occasional flooding
Lawns and Landscaping	All	Slight	
Local Roads, Streets and Parking Lots	All	Moderate	Subject to occasional flooding
Shallow Excavations (6 feet or less)	All	Severe	Subject to occasional flooding

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1/ Practices generally not applied.

EXHIBIT 3-4

Hadley very fine sandy loam, occasionally flooded or high bottom phase

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Camp Areas (Tent and Camp Trailers)	All	Moderate	Subject to occasional flooding
Picnic Areas (Park-Type)	All	Slight	
Playgrounds (Athletic Fields)	All	Moderate	Subject to occasional flooding
Paths and Trails (Hiking and Bridle)	All	Slight	

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE			
Use	Slope	Suitablity	Major Soil Feature(s) Affecting Use
Truck Crops	All	Good	
Field Crops	All	Good	
Hay and Pasture Crops	All	Good	
Apple Orchards	All	Not rated	

SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to – – –						Productivity			Species to Favor – –	
	Seedling Mortality	Plant Competition: Hardwood	Plant Competition: Conifer	Windthrow Hazard	Erosion Hazard	Equipment Restric-tions	Suit-ability Group	Major Species	Site Index Range	Existing Stands	For Planting
All	Slight	Slight	Moderate	Slight	Slight	Slight	3o1	White Pine* Red Pine Northern Hardwoods	70-80 70-80 59-66	W.P. S.M. Y.B.	W.P. R.P. W.S.

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE			
Kinds of Wildlife	Slope	Suitability	Major Soil Feature(s) Affecting Use
Openland	All	Good	
Woodland	All	Good	
Wetland	All	Very Poor	Deep to water table

* Indicator Species

USDA SCS HYATTSVILLE MD 1973

SOIL SURVEY INTERPRETATIONS

SOIL: Hartland very fine sandy loam
MAP SYMBOL(S): 30
BRIEF SOIL DESCRIPTION:

STATE: New Hampshire
DATE: 7-73
MLRA(S): 143, 144

These are well-drained soils that formed in silts and very fine sands. Typically these soils have a dark grayish-grown very fine sandy loam surface layer 6 inches thick. The subsoil between 6 and 19 inches is olive brown and light olive brown very fine sandy loam. Below this to 48 inches is dark grayish-brown, light olive brown and olive silt and very fine sand varves. These soils occupy terraces or lake plains. Slopes range from 0 to 35 percent.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING

Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No.			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHO	4	10	200				
0- 6	vfsl, sil	ML	A-4	100	100	70-90	0.6-2.0	.17-.30	5.1-6.0	Low
6-19	vfsl, sil	ML	A-4	100	100	65-85	0.6-2.0	.15-.26	5.1-6.0	Low
19-48	vfsl, sil, lvfs, si, vfs	ML, ML-CL	A-4	100	100	55-90	0.2-0.6	.10-.26	5.1-6.0	Low

Depth to Bedrock (Ft): 5+
Depth to Fragipan (Ft): ----
Depth to Seasonal High Water Table (Ft): 4-6+
Flood Hazard: None
Potential Frost Action: High
Hydrologic Group: B

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Good
Sand	Poor: excess fines
Gravel	Unsuited: excess fines
Roadfill	Poor: high potential frost action
Daily Cover For Landfill	Good

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES

Highway Location	High potential frost action, cut slopes erodible
Pond Reservoir Areas	Moderately slow permeability
Pond Embankments	Moderately slow permeability, susceptible to piping, erodible
Sprinkler Irrigation	High available water capacity
Drainage	Well-drained
Diversions and Waterways	Moderately slow permeability, high available water capacity

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Moderately slow permeability
Sewage Lagoon	A & B C, D & E	Moderate Severe	Leakage in floor of lagoon Slope
Dwellings (With Basements)	A, B & C D & E	Moderate Severe	High in fines Slope
Dwellings (Without Basements)	A, B & C D & E	Severe Severe	High potential frost action High potential frost action, slope
Lawns and Landscaping	A & B C D & E	Slight Moderate Severe	 Slope Slope
Local Roads, Streets and Parking Lots	A & B C, D & E	Severe Severe	High potential frost action High potential frost action, slope
Shallow Excavations (6 feet or less)	A & B C D & E	Slight Moderate Severe	 Slope Slope

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EXHIBIT 3-5

Hartland very fine sandy loam

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Camp Areas (Tent and Camp Trailers)	A, B & C D & E	Moderate Severe	Moderately slow permeability Slope
Picnic Areas (Park-Type)	A & B C D & E	Slight Moderate Severe	 Slope Slope
Playgrounds (Athletic Fields)	A & B C, D & E	Moderate Severe	Moderately slow permeability Slope
Paths and Trails (Hiking and Bridle)	A, B & C D E	Slight Moderate Severe	 Slope Slope

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE			
Use	Slope	Suitablity	Major Soil Feature(s) Affecting Use
Truck Crops	A B C, D & E	Good Fair Unsuited	 Erosion Slope
Field Crops	A B C D & E	Good Fair Poor Unsuited	 Slope Slope Slope
Hay and Pasture Crops	A & B C D E	Good Fair Poor Unsuited	 Slope Slope Slope
Apple Orchards	All	Not rated	

SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
	Degree of Limitation Related to – – –						Productivity			Species to Favor – –	
Slope	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restric-tions	Suit-ability Group	Major Species	Site Index Range	Existing Stands	For Planting
		Hardwood	Conifer								
A & B	Slight	Slight	Moderate	Slight	Slight	Slight	3o1	White Pine* Red Oak Northern Hardwood Red Pine	70-80 65-75 59-66 70-80	W.P. R.O. S.M. Y.B.	W.P. R.P. W.S.
C	Slight	Slight	Moderate	Slight	Moderate	Slight	3r1				
D & E	Slight	Slight	Moderate	Slight	Severe	Moderate	3r1				

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE			
Kinds of Wildlife	Slope	Suitability	Major Soil Feature(s) Affecting Use
Openland	A, B & C D & E	Good Fair	Slope Slope
Woodland	All	Good	Slope
Wetland	All	Very Poor	Deep to water table

*Indicator Species

SOIL SURVEY INTERPRETATIONS

SOIL: Limerick silt loam
MAP SYMBOL(S): 009
BRIEF SOIL DESCRIPTION:

STATE: New Hampshire
DATE: 7-73
MLRA(S): 143, 144

These are poorly drained soils that formed in recent floodwater deposits consisting mainly of very fine sand and silt. Typically these soils have a very dark grayish-brown silt loam surface layer 5 inches thick. The underlying material to 40 inches is olive gray and dark gray silt loam. Mottles are common below 5 inches. Slopes range from 0 to 3 percent. Flooding from adjacent streams occurs at least once a year.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING

Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No.			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHO	4	10	200				
0- 5	sil, vfsl	ML	A-4	100	100	60-85	0.6-2.0	.15-.30	5.1-6.5	Low
5-40	sil, vfsl	ML	A-4	100	100	55-80	0.6-2.0	.13-.26	5.6-7.3	Low

Depth to Bedrock (Ft): 5+
Depth to Fragipan (Ft): —
Depth to Seasonal High Water Table (Ft): 0-1
Flood Hazard: Severe
Potential Frost Action: High
Hydrologic Group: C

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Poor: wetness
Sand	Unsuited: excess fines
Gravel	Unsuited: excess fines
Roadfill	Poor: wetness, high potential frost action
Daily Cover For Landfill	Poor: wetness

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES

Highway Location	High water table, frequent flooding, high potential frost action
Pond Reservoir Areas	High water table, frequent flooding, moderate permeability
Pond Embankments	Moderately slow permeability,subject to piping, high water table
Sprinkler Irrigation	1/
Drainage	High water table, frequent flooding
Diversions and Waterways	1/

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	High water table, frequent flooding
Sewage Lagoon	All	Severe	Frequent flooding
Dwellings (With Basements)	All	Severe	High water table, frequent flooding
Dwellings (Without Basements)	All	Severe	High water table, frequent flooding, high potential frost action
Lawns and Landscaping	All	Severe	High water table, frequent flooding
Local Roads, Streets and Parking Lots	All	Severe	High water table, frequent flooding, high potential frost action
Shallow Excavations (6 feet or less)	All	Severe	High water table, frequent flooding

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1/ Practices generally not applied.

EXHIBIT 3-6

Limerick silt loam

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Camp Areas (Tent and Camp Trailers)	All	Severe	High water table, frequent flooding
Picnic Areas (Park-Type)	All	Severe	High water table
Playgrounds (Athletic Fields)	All	Severe	High water table, frequent flooding
Paths and Trails (Hiking and Bridle)	All	Severe	High water table

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE			
Use	Slope	Suitablity	Major Soil Feature(s) Affecting Use
Truck Crops	All	Unsuited	High water table
Field Crops	All	Unsuited	High water table
Hay and Pasture Crops	All	Poor	High water table
Apple Orchards	All	Unsuited	High water table

SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT

Slope	Degree of Limitation Related to – – –						Productivity			Species to Favor – –	
	Seedling Mortality	Plant Competition: Hardwood	Plant Competition: Conifer	Windthrow Hazard	Erosion Hazard	Equipment Restrictions	Suitability Group	Major Species	Site Index Range	Existing Stands	For Planting
All	Severe	Severe	Severe	Severe	Slight	Severe	4w1	White Pine* Red Maple Red Spruce	60-70 70-80 40-50	W.P. R.P. R.M. Hem.	W.P. W.S.

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE			
Kinds of Wildlife	Slope	Suitability	Major Soil Feature(s) Affecting Use
Openland	All	Fair	High water table, flooding
Woodland	All	Fair	High water table, flooding
Wetland	All	Good	

* Indicator Species

SOIL SURVEY INTERPRETATIONS

SOIL: Mixed alluvial land
MAP SYMBOL(S): 7
BRIEF SOIL DESCRIPTION:

STATE: New Hampshire
DATE: 7-73
MLRA(S): 143, 144

Mixed alluvial land occupies nearly level areas of the floodplain. The deposits are generally quite recent and variable in composition. High water table and frequent flooding keeps these areas wet for long periods. Slopes range from 0 to 2 percent.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING

Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No. ___			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHO	4	10	200				
Too Variable to Estimate										

Depth to Bedrock (Ft): 5+
Depth to Fragipan (Ft): ——
Depth to Seasonal High Water Table (Ft): 0-2½
Flood Hazard: Severe
Potential Frost Action: High
Hydrologic Group: B-C

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Too variable to rate
Sand	Too variable to rate
Gravel	Too variable to rate
Roadfill	Too variable to rate
Daily Cover For Landfill	Too variable to rate

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES

Highway Location	Frequent flooding, high water table
Pond Reservoir Areas	Frequent flooding, high water table
Pond Embankments	Frequent flooding, high water table
Sprinkler Irrigation	Frequent flooding, high water table
Drainage	Frequent flooding, high water table
Diversions and Waterways	Frequent flooding, high water table

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Frequent flooding, high water table
Sewage Lagoon	All	Severe	Frequent flooding, high water table
Dwellings (With Basements)	All	Severe	Frequent flooding, high water table
Dwellings (Without Basements)	All	Severe	Frequent flooding, high water table
Lawns and Landscaping	All	Severe	Frequent flooding, high water table
Local Roads, Streets and Parking Lots	All	Severe	Frequent flooding, high water table
Shallow Excavations (6 feet or less)	All	Severe	Frequent flooding, high water table

EXHIBIT 3-7

Mixed alluvial land

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Camp Areas (Tent and Camp Trailers)	All	Severe	Frequent flooding, high water table
Picnic Areas (Park-Type)	All	Severe	Frequent flooding, high water table
Playgrounds (Athletic Fields)	All	Severe	Frequent flooding, high water table
Paths and Trails (Hiking and Bridle)	All	Severe	Frequent flooding, high water table

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE			
Use	Slope	Suitablity	Major Soil Feature(s) Affecting Use
Truck Crops	All	Unsuited	Frequent flooding, high water table
Field Crops	All	Unsuited	Frequent flooding, high water table
Hay and Pasture Crops	All	Unsuited	Frequent flooding, high water table
Apple Orchards	All	Unsuited	Frequent flooding, high water table

SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
	Degree of Limitation Related to – – –						Productivity			Species to Favor – –	
Slope	Seedling Mortality	Plant Competition Hardwood	Plant Competition Conifer	Windthrow Hazard	Erosion Hazard	Equipment Restric-tions	Suit-ability Group	Major Species	Site Index Range	Existing Stands	For Planting
			Too Variable to Rate								

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE			
Kinds of Wildlife	Slope	Suitability	Major Soil Feature(s) Affecting Use
Openland	All	Unsuited	Frequent flooding, high water table
Woodland	All	Unsuited	Frequent flooding, high water table
Wetland	All	Good	

SOIL SURVEY INTERPRETATIONS

SOIL: Ondawa fine sandy loam, frequently flooded or low bottom phase
STATE: New Hampshire
MAP SYMBOL(S): 1
DATE: 7-73
BRIEF SOIL DESCRIPTION:
MLRA(S): 143, 144

These are well-drained soils that formed in sandy floodwater deposits. Typically these soils have a dark brown fine sandy loam surface layer 8 inches thick. The subsoil from 8 to 32 inches is yellowish-brown and light olive brown fine sandy loam. Below this to 48 inches is light yellowish-brown loamy fine sand. Slopes range from 0 to 3 percent. These soils are subject to flooding from adjacent streams at least once in 5 years.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING

Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No. ___			Perme-ability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHO	4	10	200				
0- 8	fsl	SM, ML	A-2 A-4	100	95-100	40-55	2.0-6.0	.11-.23	4.5-6.0	Low
8-32	fsl, sl	SM, ML	A-2 A-4	100	95-100	25-45	2.0-6.0	.09-.18	4.5-6.0	Low
32-48	lfs, s	SM, SP-SM	A-2 A-3	90-100	80-100	5-30	>6.0	.01-.13	4.5-6.0	Very Low

Depth to Bedrock (Ft): 5+
Depth to Fragipan (Ft): ———
Depth to Seasonal High Water Table (Ft): 4-6+
Flood Hazard: Severe
Potential Frost Action: Moderate
Hydrologic Group: B

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Good
Sand	Poor: excess fines
Gravel	Unsuited: excess fines
Roadfill	Fair: moderate potential frost action
Daily Cover For Landfill	Good

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES

Highway Location	Subject to frequent flooding, moderate potential frost action
Pond Reservoir Areas	Subject to frequent flooding, moderately rapid permeability
Pond Embankments	Moderate permeability, subject to piping
Sprinkler Irrigation	High available water capacity, frequent flooding
Drainage	Frequent flooding, well-drained
Diversions and Waterways	1/

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Subject to frequent flooding
Sewage Lagoon	All	Severe	Subject to frequent flooding
Dwellings (With Basements)	All	Severe	Subject to frequent flooding
Dwellings (Without Basements)	All	Severe	Subject to frequent flooding
Lawns and Landscaping	All	Severe	Subject to frequent flooding
Local Roads, Streets and Parking Lots	All	Severe	Subject to frequent flooding
Shallow Excavations (6 feet or less)	All	Severe	Subject to frequent flooding

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1/ Practice generally not applied.

EXHIBIT 3-8

Ondawa fine sandy loam, frequently flooded or low bottom phase

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Camp Areas (Tent and Camp Trailers)	All	Severe	Subject to frequent flooding
Picnic Areas (Park-Type)	All	Moderate	Subject to frequent flooding
Playgrounds (Athletic Fields)	All	Severe	Subject to frequent flooding
Paths and Trails (Hiking and Bridle)	All	Moderate	Subject to frequent flooding

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE			
Use	Slope	Suitablity	Major Soil Feature(s) Affecting Use
Truck Crops	All	Fair	Subject to frequent flooding
Field Crops	All	Fair	Subject to frequent flooding
Hay and Pasture Crops	All	Good	
Apple Orchards	All	Not rated	

SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
	Degree of Limitation Related to – – –						Productivity			Species to Favor – –	
Slope	Seedling Mortality	Plant Competition: Hardwood	Plant Competition: Conifer	Windthrow Hazard	Erosion Hazard	Equipment Restrictions	Suitability Group	Major Species	Site Index Range	Existing Stands	For Planting
All	Slight	Slight	Moderate	Slight	Slight	Slight	4o1	White Pine* Red Pine Red Spruce Northern Hardwoods	60-70 60-70 40-50 52-59	W.P. R.P. R.O. S.M. Y.B.	W.P. R.P. W.S.

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE			
Kinds of Wildlife	Slope	Suitability	Major Soil Feature(s) Affecting Use
Openland	All	Fair	Subject to frequent flooding
Woodland	All	Good	
Wetland	All	Very Poor	Deep to water table

* Indicator Species

SOIL SURVEY INTERPRETATIONS

SOIL: Ondawa fine sandy loam, occasionally flooded or high bottom phase — STATE: New Hampshire
MAP SYMBOL(S): 1H — DATE: 7-73
BRIEF SOIL DESCRIPTION: — MLRA(S): 143, 144

These are well-drained soils that formed in sandy floodwater deposits. Typically these soils have a dark brown fine sandy loam surface layer 8 inches thick. The subsoil from 8 to 32 inches is yellowish-brown and light olive brown fine sandy loam. Below this to 48 inches is light yellowish-brown loamy fine sand. Slopes range from 0 to 3 percent. These soils are subject to flooding from adjacent streams at least once in 5 to 10 years.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING

Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No.			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHO	4	10	200				
0-8	fsl	SM, ML	A-2 A-4	100	95-100	40-55	2.0-6.0	.11-.23	4.5-6.0	Low
8-32	fsl, sl	SM, ML	A-2 A-4	100	95-100	25-45	2.0-6.0	.09-.18	4.5-6.0	Low
32-48	lfs, s	SM, SP-SM	A-2 A-3	90-100	80-100	5-30	>6.0	.01-.13	4.5-6.0	Very Low

Depth to Bedrock (Ft): 5+ — Depth to Fragipan (Ft): —— — Depth to Seasonal High Water Table (Ft): 4-6+
Flood Hazard: Moderate — Potential Frost Action: Moderate — Hydrologic Group: B

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Good
Sand	Poor: excess fines
Gravel	Unsuited: excess fines
Roadfill	Fair: moderate potential frost action
Daily Cover For Landfill	Good

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES

Highway Location	Subject to occasional flooding
Pond Reservoir Areas	Subject to occasional flooding, moderately rapid permeability
Pond Embankments	Moderate permeability, subject to piping
Sprinkler Irrigation	High available water capacity, occasional flooding
Drainage	Occasional flooding, well-drained
Diversions and Waterways	1/

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Subject to occasional flooding
Sewage Lagoon	All	Severe	Subject to occasional flooding
Dwellings (With Basements)	All	Severe	Subject to occasional flooding
Dwellings (Without Basements)	All	Severe	Subject to occasional flooding
Lawns and Landscaping	All	Slight	
Local Roads, Streets and Parking Lots	All	Moderate	Subject to occasional flooding
Shallow Excavations (6 feet or less)	All	Severe	Subject to occasional flooding

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1/ Practice generally not applied.

EXHIBIT 3-9

Ondawa fine sandy loam, occasionally flooded or high bottom phase

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Camp Areas (Tent and Camp Trailers)	All	Moderate	Subject to occasional flooding
Picnic Areas (Park-Type)	All	Slight	
Playgrounds (Athletic Fields)	All	Moderate	Subject to occasional flooding
Paths and Trails (Hiking and Bridle)	All	Slight	

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE			
Use	Slope	Suitablity	Major Soil Feature(s) Affecting Use
Truck Crops	All	Good	
Field Crops	All	Good	
Hay and Pasture Crops	All	Good	
Apple Orchards	All	Not rated	

SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT

Slope	Degree of Limitation Related to – – –						Productivity			Species to Favor – –	
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restric-tions	Suit-ability Group	Major Species	Site Index Range	Existing Stands	For Planting
		Hardwood	Conifer								
All	Slight	Slight	Moderate	Slight	Slight	Slight	4o1	White Pine* Red Pine Red Spruce Northern Hardwoods	60-70 60-70 40-50 52-59	W.P. R.P. R.O. S.M. Y.B.	W.P. R.P. W.S.

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE			
Kinds of Wildlife	Slope	Suitability	Major Soil Feature(s) Affecting Use
Openland	All	Good	
Woodland	All	Good	
Wetland	All	Very Poor	Deep to water table

* Indicator Species

SOIL SURVEY INTERPRETATIONS

SOIL: Ondawa sandy loam — STATE: New Hampshire

MAP SYMBOL(S): 25 — DATE: 7-73

BRIEF SOIL DESCRIPTION: — MLRA(S): 143, 144

These are well-drained soils that formed in sandy floodwater deposits. Typically these soils have a dark brown sandy loam surface layer 8 inches thick. The subsoil from 8 to 32 inches is yellowish-brown and light olive brown sandy loam. Below this to 48 inches is light yellowish-brown loamy sand. Slopes range from 0 to 3 percent. These soils are subject to flooding from adjacent streams at least once in 5 years.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING

Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No. ___			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHO	4	10	200				
0- 8	sl	SM, ML	A-2 A-4	100	95-100	30-55	2.0-6.0	.11-.18	4.5-6.0	Low
8-32	sl, fsl	SM	A-2	100	95-100	25-45	2.0-6.0	.09-.18	4.5-6.0	Low
32-48	ls, s	SM, SP-SM	A-2 A-3	90-100	80- 95	5-30	>6.0	.01-.13	4.5-6.0	Very Low

Depth to Bedrock (Ft): 5+ — Depth to Fragipan (Ft): —— — Depth to Seasonal High Water Table (Ft): 4-6+

Flood Hazard: Severe — Potential Frost Action: Moderate — Hydrologic Group: B

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Good
Sand	Poor: excess fines
Gravel	Unsuited: excess fines
Roadfill	Fair: moderate potential frost action
Daily Cover For Landfill	Good

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES

Highway Location	Subject to frequent flooding, moderate potential frost action
Pond Reservoir Areas	Subject to frequent flooding, moderately rapid permeability
Pond Embankments	Moderate permeability, subject to piping
Sprinkler Irrigation	Moderate available water capacity, frequent flooding
Drainage	Subject to frequent flooding, well-drained
Diversions and Waterways	1/

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Subject to frequent flooding
Sewage Lagoon	All	Severe	Subject to frequent flooding
Dwellings (With Basements)	All	Severe	Subject to frequent flooding
Dwellings (Without Basements)	All	Severe	Subject to frequent flooding
Lawns and Landscaping	All	Severe	Subject to frequent flooding
Local Roads, Streets and Parking Lots	All	Severe	Subject to frequent flooding
Shallow Excavations (6 feet or less)	All	Severe	Subject to frequent flooding

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1/ Practice generally not applied.

EXHIBIT 3-10

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Camp Areas (Tent and Camp Trailers)	All	Severe	Subject to frequent flooding
Picnic Areas (Park-Type)	All	Moderate	Subject to frequent flooding
Playgrounds (Athletic Fields)	All	Severe	Subject to frequent flooding
Paths and Trails (Hiking and Bridle)	All	Moderate	Subject to frequent flooding

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE

Use	Slope	Suitability	Major Soil Feature(s) Affecting Use
Truck Crops	All	Fair	Subject to frequent flooding
Field Crops	All	Fair	Subject to frequent flooding
Hay and Pasture Crops	All	Good	
Apple Orchards	All	Not rated	

Paths and Trails (Hiking and Bridle)	All	Moderate	Subject to frequent flooding

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE

Use	Slope	Suitability	Major Soil Feature(s) Affecting Use
Truck Crops	All	Fair	Subject to frequent flooding

SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT

Slope	Degree of Limitation Related to – – –						Productivity			Species to Favor – –	
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restrictions	Suitability Group	Major Species	Site Index Range	Existing Stands	For Planting
		Hardwood	Conifer								
All	Slight	Slight	Moderate	Slight	Slight	Slight	4o1	White Pine* Red Pine Red Spruce* Northern Hardwoods*	60-70 60-70 40-50 52-59	W.P. R.P. R.O.	W.P. R.P. W.S.

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE

Kinds of Wildlife	Slope	Suitability	Major Soil Feature(s) Affecting Use
Openland	All	Fair	Subject to frequent flooding
Woodland	All	Good	
Wetland	All	Very Poor	Deep to water table

* Indicator Species

SOIL SURVEY INTERPRETATIONS

SOIL: Podunk fine sandy loam
STATE: New Hampshire
MAP SYMBOL(S): 4
DATE: 7-73
BRIEF SOIL DESCRIPTION
MLRA(S): 143, 144

These are moderately well drained soils that formed in sandy floodwater deposits. Typically these soils have a dark yellowish-brown fine sandy loam surface layer 8 inches thick. The subsoil from 8 to 30 inches is light olive brown fine sandy loam. Below this to 48 inches is olive gray loamy fine sand. Slopes range from 0 to 3 percent. These soils are subject to flooding from adjacent streams at least once in 5 years.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING

Depth From Surface (Inches)	Classification: USDA Texture	Classification: Unified	Classification: AASHO	Percentage Less Than 3 Inches Passing Sieve No. —: 4	10	200	Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
0- 8	fsl, sl	SM, ML	A-4	95-100	90-100	35-55	0.6-2.0	.11-.23	4.5-6.0	Low
8-30	fsl, sl	SM	A-2 A-4	95-100	85- 95	30-50	2.0-6.0	.08-.17	4.5-6.0	Low
30-48	lfs, ls, s	SM, SP-SM	A-2 A-3	90-100	80-100	5-30	2.0-6.0	.01-.13	4.5-6.0	Low

Depth to Bedrock (Ft): 5+
Depth to Fragipan (Ft): ——
Depth to Seasonal High Water Table (Ft): 1-2½
Flood Hazard: Severe
Potential Frost Action: High
Hydrologic Group: B

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Good
Sand	Poor1/: excess fines
Gravel	Unsuited: excess fines
Roadfill	Poor: high potential frost action
Daily Cover For Landfill	Good

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES*

Highway Location	Seasonal high water table, frequent flooding, high potential frost action
Pond Reservoir Areas	Moderately rapid permeability, seasonal high water table, frequent flooding
Pond Embankments	Moderate permeability, subject to piping
Sprinkler Irrigation	Seasonal high water table, moderate available water capacity
Drainage	Seasonal high water table, moderately rapid permeability, frequent flooding
Diversions and Waterways	Frequent flooding, nearly level slopes

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Seasonal high water table, frequent flooding
Sewage Lagoon	All	Severe	Frequent flooding, moderately rapid permeability
Dwellings (*With Basements*)	All	Severe	Seasonal high water table, frequent flooding
Dwellings (Without Basements)	All	Severe	Subject to frequent flooding, high potential frost action
Lawns and Landscaping	All	Severe	Frequent flooding
Local Roads, Streets and Parking Lots	All	Severe	Frequent flooding, high potential frost action
Shallow Excavations (6 feet or less)	All	Severe	Frequent flooding

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1/ Rating is fair below 2 1/2 feet.

EXHIBIT 3-11

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Camp Areas (Tent and Camp Trailers)	All	Severe	Subject to frequent flooding
Picnic Areas (Park-Type)	All	Moderate	Subject to frequent flooding
Playgrounds (Athletic Fields)	All	Severe	Subject to frequent flooding
Paths and Trails (Hiking and Bridle)	All	Slight	

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE			
Use	Slope	Suitability	Major Soil Feature(s) Affecting Use
Truck Crops	All	Poor	Subject to frequent flooding
Field Crops	All	Fair	Subject to frequent flooding
Hay and Pasture Crops	All	Good	
Apple Orchards	All	Unsuited	Subject to frequent flooding

SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
	Degree of Limitation Related to - - -						Productivity			Species to Favor - -	
Slope	Seedling Mortality	Plant Competition Hardwood	Plant Competition Conifer	Windthrow Hazard	Erosion Hazard	Equipment Restrictions	Suitability Group	Major Species	Site Index Range	Existing Stands	For Planting
All	Slight	Slight	Moderate	Slight	Slight	Slight	3o1	White Pine* Red Oak Northern Hardwoods Red Pine	70-80 65-75 59-66 70-80	W.P. R.P. R.O. S.M. W.A. Y.B.	W.P. R.P. W.S.

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE			
Kinds of Wildlife	Slope	Suitability	Major Soil Feature(s) Affecting Use
Openland	All	Fair	Subject to frequent flooding
Woodland	All	Good	
Wetland	All	Poor	Fluctuating water table

* Indicator Species

SOIL SURVEY INTERPRETATIONS

SOIL: Podunk fine sandy loam, over sand or gravel — STATE: New Hampshire
MAP SYMBOL(S): 4C — DATE: 7-73
BRIEF SOIL DESCRIPTION: — MLRA(S) 143, 144

These are moderately well drained soils that formed in sandy floodwater deposits. Typically these soils have a dark yellowish-brown fine sandy loam surface layer 8 inches thick. The subsoil from 8 to 28 inches is light olive brown fine sandy loam. Below this to 46 inches is olive gray sand or gravel. Slopes range from 0 to 3 percent. These soils are subject to flooding from adjacent streams at least once in 5 years.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING

Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No.			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHO	4	10	200				
0- 8	fsl, sl	SM, ML	A-4	95-100	90-100	35-55	2.0-6.0	.11-.23	4.5-6.0	Low
8-28	fsl, sl	SM	A-2 A-4	95-100	85- 95	30-50	2.0-6.0	.08-.17	4.5-6.0	Low
28-49	sand or gravel	SP, GP	A-1 A-2	40- 70	35- 65	0- 5	>6.0	.01-.05	4.5-5.5	Very Low

Depth to Bedrock (Ft): 5+ — Depth to Fragipan (Ft): —— — Depth to Seasonal High Water Table (Ft): 1-2½

Flood Hazard: Severe — Potential Frost Action: High — Hydrologic Group: B

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Good
Sand	Poor 1/: excess fines
Gravel	Poor 1/: excess fines
Roadfill	Poor: high potential frost action
Daily Cover For Landfill	Good

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES

Highway Location	Seasonal high water table, frequent flooding, high potential frost action
Pond Reservoir Areas	Rapid permeability in substratum, seasonal high water table, frequent flooding
Pond Embankments	Moderate permeability, subject to piping
Sprinkler Irrigation	Moderate available water capacity, seasonal high water table
Drainage	Seasonal high water table, moderately rapid permeability, frequent flooding
Diversions and Waterways	Frequent flooding, sand or gravel layers below about 2½, nearly level slopes

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Seasonal high water table, frequent flooding
Sewage Lagoon	All	Severe	Frequent flooding, moderately rapid permeability
Dwellings (With Basements)	All	Severe	Seasonal high water table, frequent flooding
Dwellings (Without Basements)	All	Severe	Subject to frequent flooding, high potential frost action
Lawns and Landscaping	All	Severe	Frequent flooding
Local Roads, Streets and Parking Lots	All	Severe	Frequent flooding, high potential frost action
Shallow Excavations (6 feet or less)	All	Severe	Frequent flooding

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1/ Rating is good below about 2½ feet.

EXHIBIT 3-12

EXHIBIT 3-13

Windsor loamy sand

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT			
Use	**Slope**	**Degree of Limitation**	**Major Soil Feature(s) Affecting Use**
Camp Areas (Tent and Camp Trailers)	A, B & C D & E	Moderate Severe	Sandy Slope
Picnic Areas (Park-Type)	A, B & C D & E	Moderate Severe	Sandy Slope
Playgrounds (Athletic Fields)	A & B C, D & E	Moderate Severe	Sandy Slope
Paths and Trails (Hiking and Bridle)	A, B, C & D E	Moderate Severe	Sandy Slope

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE			
Use	**Slope**	**Suitability**	**Major Soil Feature(s) Affecting Use**
Truck Crops	A & B C, D & E	Poor Unsuited	Droughty Slope
Field Crops	A & B C, D & E	Poor Unsuited	Droughty Slope
Hay and Pasture Crops	A & B C D & E	Fair Poor Unsuited	Droughty Slope Slope
Apple Orchards	All	Unsuited	Droughty, slope

SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT

Slope	Degree of Limitation Related to – – –						Productivity			Species to Favor – –	
	Seedling Mortality	Plant Competition: Hardwood	Plant Competition: Conifer	Windthrow Hazard	Erosion Hazard	Equipment Restrictions	Suitability Group	Major Species	Site Index Range	Existing Stands	For Planting
A, B & C	Severe	Slight	Slight	Slight	Slight	Slight	5s1	White Pine* Red Pine Red Oak	50-60 50-60 45-55	W.P. R.P. R.O.	W.P. R.P.
D & E	Severe	Slight	Slight	Slight	Slight 3/	Moderate 4/	5s1				

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE			
Kinds of Wildlife	**Slope**	**Suitability**	**Major Soil Feature(s) Affecting Use**
Openland	All	Poor	Droughty
Woodland	All	Poor	Droughty
Wetland	All	Very Poor	No water

* Indicator Species

3/ Rating is moderate when slopes are greater than 35 percent.

4/ Rating is severe when slopes are greater than 35 percent.

USDA SCS HYATTSVILLE MD 1973

SOIL SURVEY INTERPRETATIONS

SOIL: Windsor loamy sand, dark mineral substratum phase
MAP SYMBOL(S): 326
BRIEF SOIL DESCRIPTION:

STATE: New Hampshire
DATE: 7-73
MLRA(S) 143, 144

These are excessively drained soils that formed in thick deposits of sand. Typically these soils have a dark brown loamy sand surface layer 8 inches thick. The subsoil to 16 inches is yellowish-brown and light olive brown loamy sand. Below this to 50 inches is very dark gray and gray sand. These soils occupy terraces, outwash plains and deltas. Slopes range from 0 to 60 percent.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING

Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No.			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHO	4	10	200				
0- 8	ls, lfs	SM	A-2	95-100	90-100	20-35	>6.0	.08-.15	4.5-6.5	Very Low
8-16	ls, lfs	SM	A-2	95-100	90-100	15-30	>6.0	.06-.13	4.5-6.5	Very Low
16-50	s, fs	SP, SM	A-2 A-3	90-100	85-100	0-20	>6.0	.01-.08	4.5-6.5	Very Low

Depth to Bedrock (Ft): 6-8+
Depth to Fragipan (Ft): ----
Depth to Seasonal High Water Table (Ft): 6+
Flood Hazard: None
Potential Frost Action: Low
Hydrologic Group: A

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Poor: sandy
Sand	Good
Gravel	Poor: excess fines
Roadfill	Good
Daily Cover For Landfill	Fair: sandy

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES

Highway Location	Cut slopes unstable, erodible
Pond Reservoir Areas	Rapid permeability
Pond Embankments	Rapid permeability, erodible
Sprinkler Irrigation	Very low available water capacity
Drainage	1/
Diversions and Waterways	Rapid permeability, very low available water capacity

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	A & B C D & E	Slight 2/ Moderate 2/ Severe	 Slope Slope
Sewage Lagoon	A & B C, D & E	Severe 2/ Severe 2/	Rapid permeability Rapid permeability, slope
Dwellings (With Basements)	A & B C D & E	Slight Moderate Severe	 Slope Slope
Dwellings (Without Basements)	A & B C D & E	Slight Moderate Severe	 Slope Slope
Lawns and Landscaping	A, B & C D & E	Severe Severe	Droughty Droughty, slope
Local Roads, Streets and Parking Lots	A B C, D & E	Slight Moderate Severe	 Slope Slope
Shallow Excavations (6 feet or less)	A, B & C D & E	Severe Severe	Sloughing Sloughing, slope

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1/ Practice generally not applied.

2/ Potential pollution hazard to nearby wells, streams and lakes.

EXHIBIT 3-15

Windsor loamy sand, dark mineral substratum phase

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Camp Areas (Tent and Camp Trailers)	A, B & C D & E	Moderate Severe	Sandy Slope
Picnic Areas (Park-Type)	A, B & C D & E	Moderate Severe	Sandy Slope
Playgrounds (Athletic Fields)	A & B C, D & E	Moderate Severe	Sandy Slope
Paths and Trails (Hiking and Bridle)	A, B, C & D E	Moderate Severe	Sandy Slope

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE			
Use	Slope	Suitablity	Major Soil Feature(s) Affecting Use
Truck Crops	A & B C, D & E	Poor Unsuited	Droughty Slope
Field Crops	A & B C, D & E	Poor Unsuited	Droughty Slope
Hay and Pasture Crops	A & B C D & E	Fair Poor Unsuited	Droughty Slope Slope
Apple Orchards	All	Unsuited	Droughty, slope

SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
	Degree of Limitation Related to - - -						Productivity			Species to Favor - -	
Slope	Seedling Mortality	Plant Competition: Hardwood	Plant Competition: Conifer	Windthrow Hazard	Erosion Hazard	Equipment Restric-tions	Suit-ability Group	Major Species	Site Index Range	Existing Stands	For Planting
A, B & C	Severe	Slight	Slight	Slight	Slight	Slight	5s1	White Pine* Red Pine Red Oak	50-60 50-60 45-55	W.P. R.P. R.O.	W.P. R.P.
D & E	Severe	Slight	Slight	Slight	Slight3/	Moderate4/	5s1				

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE			
Kinds of Wildlife	Slope	Suitability	Major Soil Feature(s) Affecting Use
Openland	All	Poor	Droughty
Woodland	All	Poor	Droughty
Wetland	All	Very Poor	No water

* Indicator Species

3/ Rating is moderate when slopes are greater than 35 percent.

4/ Rating is severe when slopes are greater than 35 percent.

USDA SCS HYATTSVILLE MD 1973

SOIL SURVEY INTERPRETATIONS

SOIL: Winooski very fine sandy loam
MAP SYMBOL(S): 9
BRIEF SOIL DESCRIPTION:

STATE: New Hampshire
DATE: 7-73
MLRA(S): 143, 144

These are moderately well drained soils that formed in recent very fine sand and silt floodwater deposits. Typically these soils have a very dark grayish-brown very fine sandy loam surface layer 9 inches thick. Below this to 42 inches is dark grayish-brown and grayish-brown silt loam and very fine sandy loam. Slopes range from 0 to 3 percent. These soils are subject to flooding from adjacent streams at least once in 5 years.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING

Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No.			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHO	4	10	200				
0- 9	vfsl, sil	ML	A-4	100	95-100	65-90	0.6-2.0	.16-.29	5.1-6.5	Low
9-42	vfsl, sil	ML	A-4	100	90-100	60-85	0.6-2.0	.13-.26	5.1-7.3	Low

Depth to Bedrock (Ft): 5+
Depth to Fragipan (Ft): —
Depth to Seasonal High Water Table (Ft): 1-3
Flood Hazard: Severe
Potential Frost Action: High
Hydrologic Group: B

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Good
Sand	Unsuited: excess fines
Gravel	Unsuited: excess fines
Roadfill	Poor: high potential frost action
Daily Cover For Landfill	Good

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES

Highway Location	Seasonal high water table, frequent flooding, high potential frost action
Pond Reservoir Areas	Moderate permeability, seasonal high water table, frequent flooding
Pond Embankments	Moderately slow permeability, subject to piping
Sprinkler Irrigation	Seasonal high water table, high available water capacity
Drainage	Seasonal high water table, moderate permeability, frequent flooding
Diversions and Waterways	Frequent flooding, nearly level slopes

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Seasonal high water table, frequent flooding
Sewage Lagoon	All	Severe	Frequent flooding
Dwellings (With Basements)	All	Severe	Seasonal high water table, frequent flooding
Dwellings (Without Basements)	All	Severe	Frequent flooding, high potential frost action
Lawns and Landscaping	All	Severe	Frequent flooding
Local Roads, Streets and Parking Lots	All	Severe	Frequent flooding, high potential frost action
Shallow Excavations (6 feet or less)	All	Severe	Frequent flooding

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EXHIBIT 3-16

Winooski very fine sandy loam

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Camp Areas (Tent and Camp Trailers)	All	Moderate	Flooding
Picnic Areas (Park-Type)	All	Moderate	Flooding
Playgrounds (Athletic Fields)	All	Moderate	Flooding
Paths and Trails (Hiking and Bridle)	All	Slight	

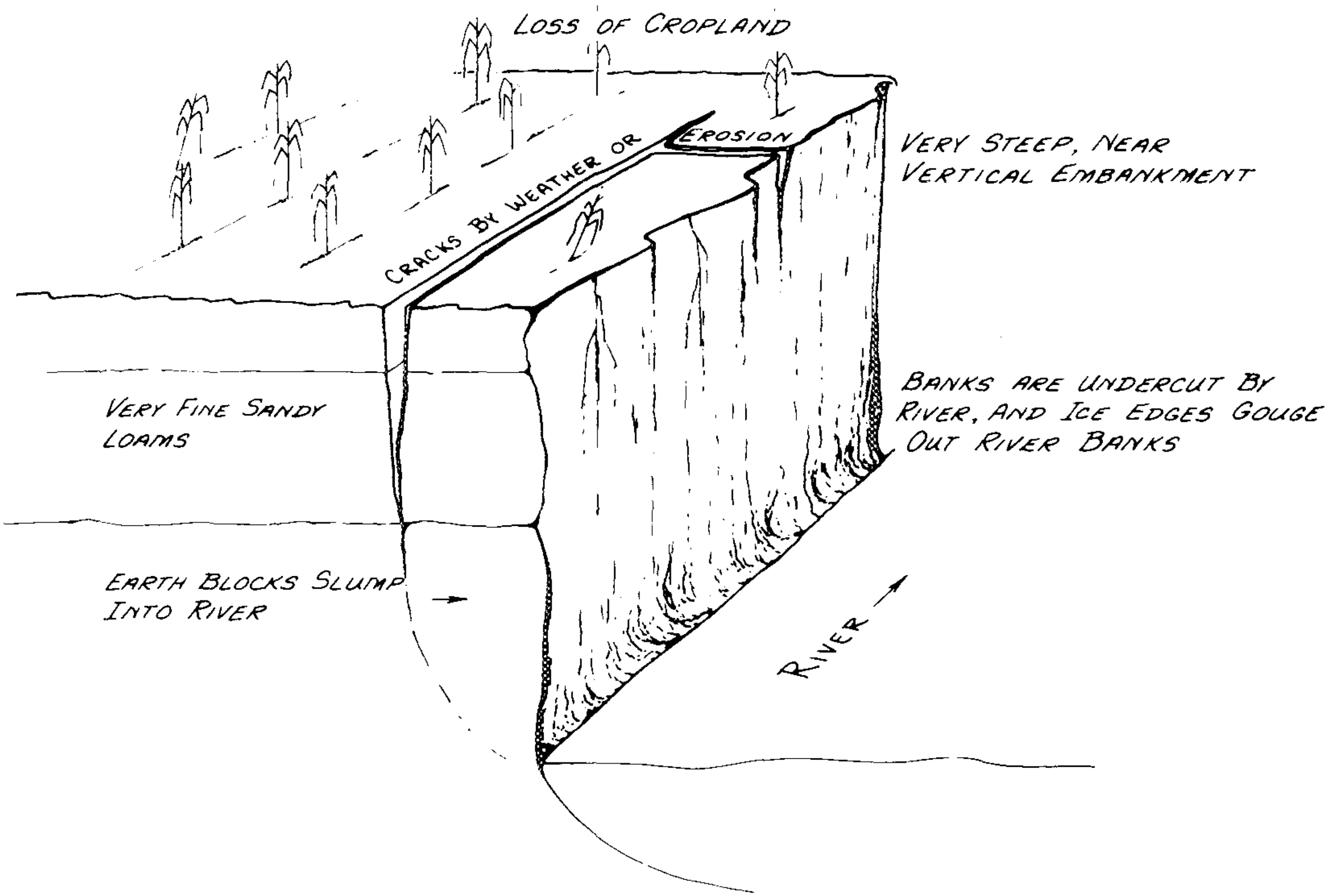
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE			
Use	Slope	Suitablity	Major Soil Feature(s) Affecting Use
Truck Crops	All	Poor	Frequent flooding
Field Crops	All	Fair	Frequent flooding
Hay and Pasture Crops	All	Good	
Apple Orchards	All	Unsuited	Frequent flooding

SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to – – –						Productivity			Species to Favor – –	
	Seedling Mortality	Plant Competition: Hardwood	Plant Competition: Conifer	Windthrow Hazard	Erosion Hazard	Equipment Restric-tions	Suit-ability Group	Major Species	Site Index Range	Existing Stands	For Planting
All	Slight	Slight	Moderate	Slight	Slight	Slight	3o1	White Pine* Red Oak Northern Hardwoods	70-80 65-75 60-70	W.P. S.M. Y.B. R.O.	W.P. R.P.

SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE			
Kinds of Wildlife	Slope	Suitability	Major Soil Feature(s) Affecting Use
Openland	All	Fair	Frequent flooding
Woodland	All	Good	
Wetland	All	Poor	Seasonal high water table

* Indicator Species

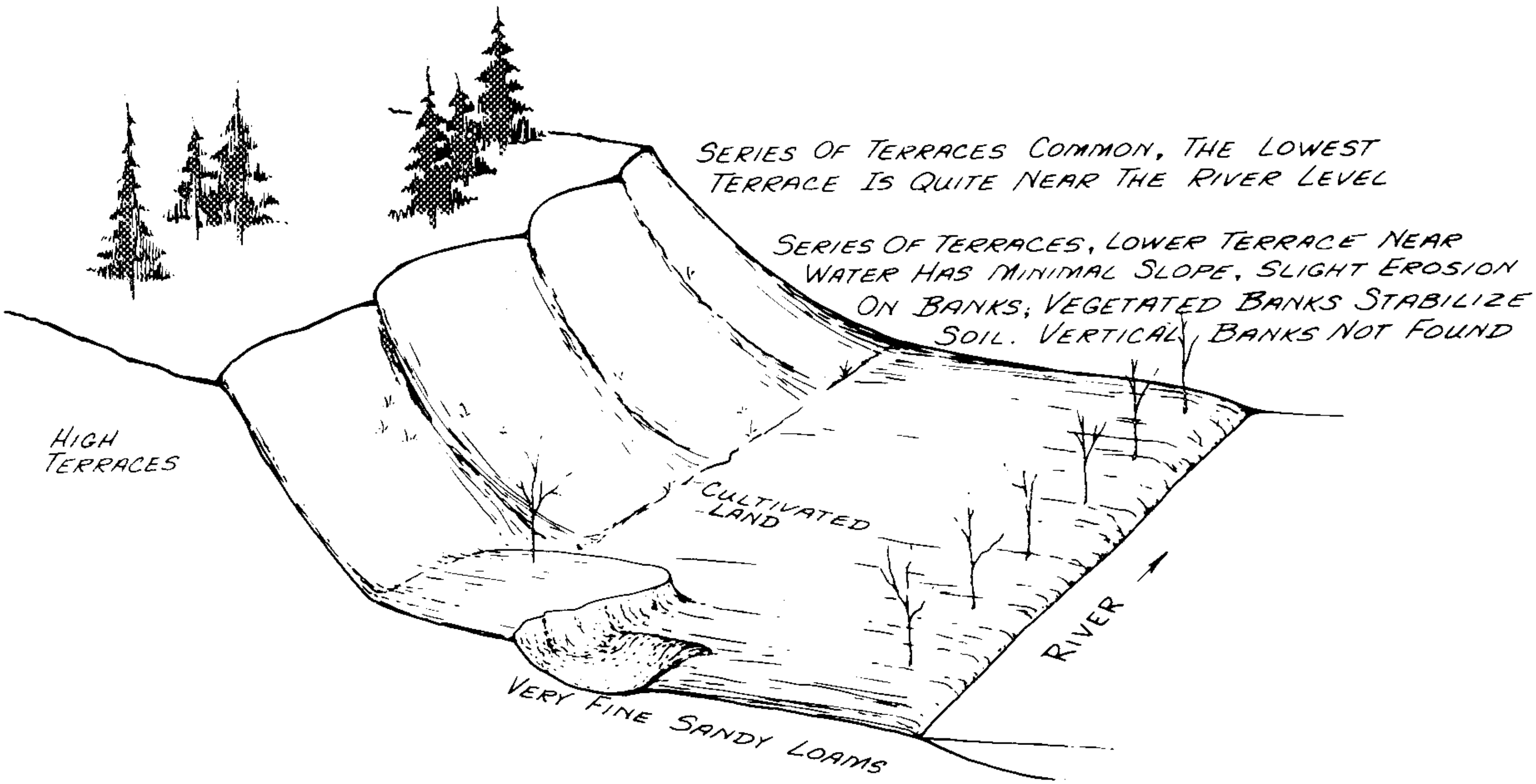
USDA SCS HYATTSVILLE MD 1973



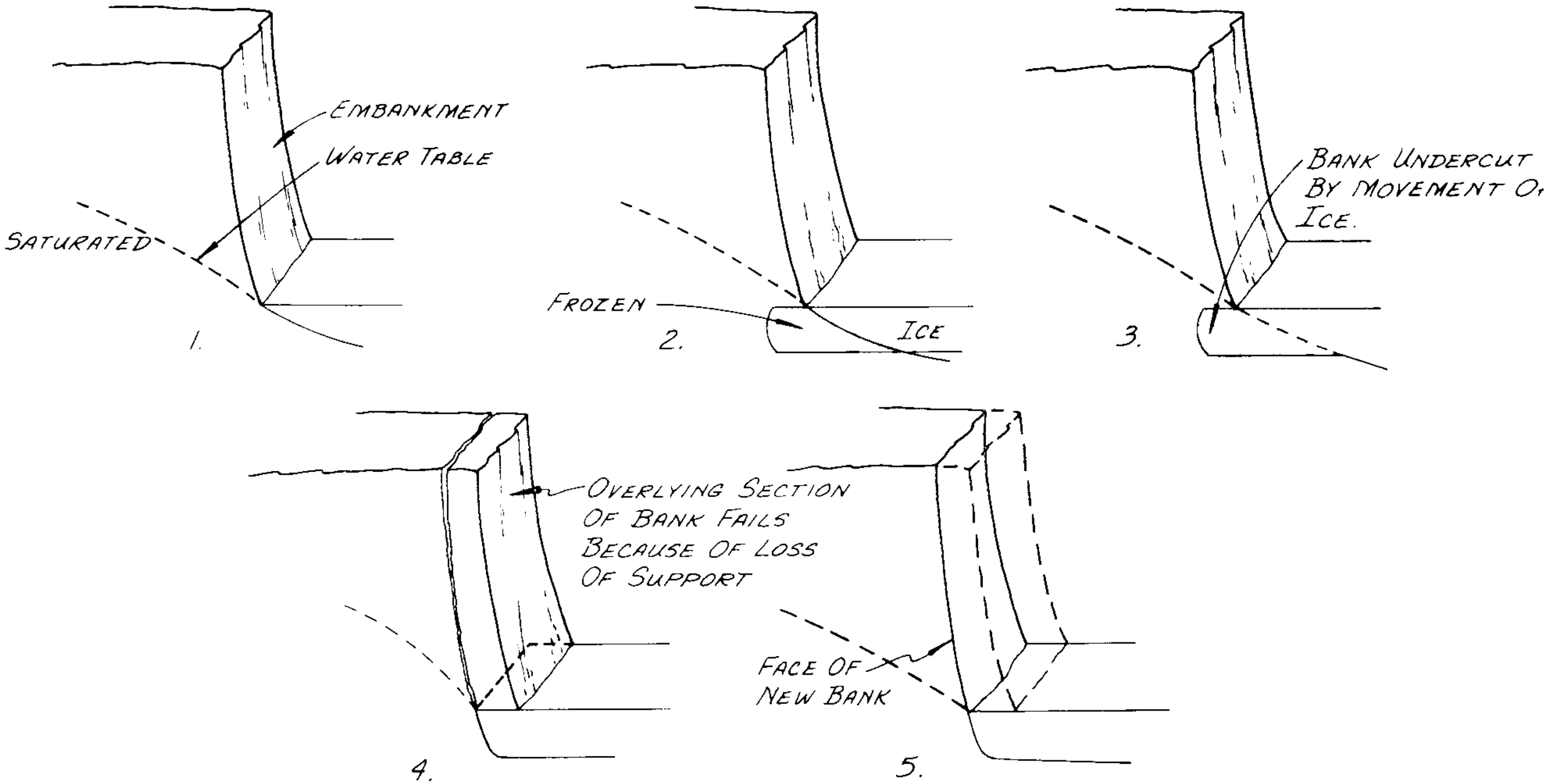
TYPICAL SOIL EROSION AND MASS WASTING

CHARLESTOWN, SULLIVAN COUNTY, N.H.

EXHIBIT 4-1



TYPICAL LANDSCAPE, NORTH OF ASCUTNEY BRIDGE
SULLIVAN COUNTY
EXHIBIT 5-1



REMOVAL OF SOIL MATERIAL BY
ANCHOR ICE

EXHIBIT 6-1

REPORT BY
NEW ENGLAND POWER COMPANY
TO
TECHNICAL COMMITTEE ON BANK EROSION
ON THE CONNECTICUT RIVER

I. GENERAL

Erosion of the banks of natural rivers is an ever-continuing process, accompanied by deposition in some locations as material is being eroded in others. Where currents are swift, banks are cut away; and where flow is sluggish, accretion occurs, resulting in a meandering river course, featured by ox-bows continually changing in location. As a result, over a long period of time, a wide flood plain is carved out, many times the width of the actual stream.

Similar action occurs when river flow is ponded by a dam or other obstruction; and although this action is retarded by less severe seasonal fluctuation and lower velocities than in a natural river, it continues to exist because the current acts on a higher and sometimes steeper section of river bank.

There are several causes of bank erosion. Some of the more common ones are as follows:

1. Ice Action -- Pond ice can form to a depth of several feet and with pond fluctuation can transmit stress to a river bank and scour material as it pulls loose. The most damage takes place during ice runs when natural grinding action occurs and can be quite severe where jamming occurs.

2. Wave Action -- The undulation of wave action can cause erosion; and where power boat operation is prevalent, this can be a severe condition.

3. Current Velocity -- When the velocity of the water is high enough to move particles of silt or sand, washing or undercutting can occur.

4. Leaching and Piping -- Where shore lines are high or steep, surface or underground drainage can cause washing out of fine materials destroying the stability of the river banks.

5. Pond Drawdown -- Although the descent of the adjoining water level actually increases the stability of banks composed of incompressible soils, it reduces the stability of banks composed of compressible soils since water is retained in the bank by capillary forces and a volume decrease takes place due to consolidation.

6. Other Factors -- Banks may be kept raw by the passage of cow herds, may be honeycombed by bank swallows, may be weakened by falling trees, or may be affected by human disruption such as vegetative clearing, earth moving, building and paving.

II. OPERATION OF PONDS

1. Drawdown Limits

At Wilder Dam, normal pond elevation varies from 385.0 to 380.0 msl. At Bellows Falls Dam, normal pond elevation varies from 291.63 to 287.63 msl. At Vernon Dam, normal pond elevation varies from 220.13 to 212.13 msl.

It should be noted that, because of backwater effects, the variation can be much greater than this at the upper reaches of the ponds, depending on the magnitude of river flow. This variation, however, is still much less than the variation of natural river elevations without the dams.

Except under emergency conditions, water level is never drawn below these limits.

2. Rates of Drawdown

At Wilder Dam, the pond cannot be drawn more than 0.4 feet per hour, measured at the dam, by generation alone, even with no inflow.

At Bellows Falls Dam, the amount of generation for a given pond elevation is limited in order to limit the velocity in the Bellows Falls Canal to 6 feet per second. This restriction limits the drawdown of the pond to 0.4 feet per hour, measured at the dam, by generation alone, even with no inflow.

At Vernon Dam, the pond cannot be drawn more than 0.5 feet per hour, measured at the dam, by generation alone, even with no inflow.

It is, of course, possible to draw the ponds at faster rates by gate operation. However, to prevent the quantity of water being discharged from greatly exceeding the inflow thereby increasing the magnitude of downstream flooding, restrictions are imposed during high water periods which limit drawdown rates to less than those listed above for generation alone.

Because of backwater effect and upstream natural channel controls, the amount of drawdown, as measured at the various dams, diminishes progressively as one moves upstream. Consequently, a rate of draw established at the dam would be considerably greater under most circumstances than that actually experienced in the upper reaches of the pond.

It should also be noted that the rates and depths of drawdown resulting from natural ice movement may far exceed the operating limitations imposed on the various ponds.

3. Inspections

Bank inspections by boat, using maps and photographs, have been made on each of these ponds periodically for over 20 years. Surprisingly, bank erosion has occurred at a much slower rate than one would think from looking at the scars and raw areas. This is borne out by observations made over many years using specific trees or landmarks and comparing the distance of these objects from the top of river bank at each inspection.

Where significant erosion has occurred, it has generally been accompanied by severe flow conditions or heavy ice runs.

III. EXTENT AND NATURE OF EROSION

Less than ten percent of the shoreline of these ponds shows evidence of erosion. Even this figure is deceivingly large, however, since a large proportion of this percentage consists of inactive slide areas, which have stabilized and are healing.

The nature of the erosion indicates that no single factor is responsible. Actually, it appears that a combination of all the causes listed in Section I of this report has led to the existing conditions.

An inspection, including photographs, of sections of the river where no impoundment takes place and of the shoreline of the White River, which has no dams, indicates that erosion is more severe and more extensive in those areas than along the pond banks.

IV. RELATION OF PROBLEM TO RELICENSING

In compliance with Federal Power Commission regulations, prior to construction or redevelopment of these three dams, comprehensive flowage rights were obtained from all property owners abutting the pond areas and agreements and indentures obtained from all towns having rights-of-way adjoining the impoundments. In addition, stream bank erosion is considered less severe in the impounded section of the river than in the non-impounded section.

The New England Power Company, therefore, believes there is no erosion problem with regard to relicensing since all regulatory requirements have been met including, at considerable cost, acquisition of all necessary lands and rights for flow along the banks of the impoundments.

V. CONCLUSIONS

It is our conclusion that erosion along the banks of Wilder, Bellows Falls and Vernon Dams is a natural phenomenon, attributable to natural causes, and that, rather than adding to this erosion, the Company's operation of these ponds by reducing velocities and fluctuation ranges and by reducing flood discharges through storage in upstream reservoirs, actually decreases the condition, resulting in more stable conditions than exist where no impoundment takes place.

We would discourage the construction of residences within the confines of the flood plain of the Connecticut River, since this introduces problems completely beyond our control.

EFFECTS OF BANK EROSION ON THE BIOLOGICAL RESOURCES OF THE CONNECTICUT RIVER

U. S. Bureau of Sport Fisheries and Wildlife

Introduction

There can be little question that a serious silt condition exists in certain sections of the Connecticut River, especially upstream from the Vernon Dam. During the spring and early summer months, the silt load is such that Secchi disc readings are almost non-existent. The disc disappears within a short distance from the surface.

It initially appears that a substantial portion of the silt load in the river is caused by the gradual and continuous sloughing off of the river bank. Although erosion is undoubtedly a common and naturally occurring condition in nature, the situation in the Connecticut River appears to be aggravated by the manipulation of the water levels during hydroelectric power generation. It appears that the constant daily, weekly and seasonal fluctuations preclude the possibilities of the banks ever being able to stabilize themselves with any degree of success.

Abnormal riverine patterns of silt deposition may be seen in river segments directly affected by water level manipulation. This is illustrated in Figure 1.

Fishery Resources Available

The Connecticut River primarily supports a warmwater fishery resource. Principal game fish species found in the area under investigation include smallmouth and largemouth bass, sunfish, walleye, yellow perch, brown and yellow bullheads, northern pike and chain pickerel. Forage species found in this area include suckers, fallfish, and golden shiners. Bass, sunfish, bullheads, suckers, and fallfish utilize gravel or sand bottoms. Their nests are generally found in a depth range of 2' to 8'.

Utilization of the Connecticut River's fishery resources is currently below the potential support capacity. Increases in human population will probably produce additional fishing pressure upon the main stem Connecticut River. It is, therefore, important to retain the conditions necessary for perpetuation of the fishery resources.

Preliminary Determination of Erosion Pattern Effects Upon the River's Biological Resources

One of the most significant findings to come from the resident fish population studies on the Connecticut River was the overall low density of the various fish populations. This was particularly obvious in certain areas and in the Vernon Pool.

Not only were there low population densities of adult fishes, but a definite absence of "zero" age class fish; that is, fish of the year which should have been the most prevalent of all. This is a good indication of poor egg hatching. Recent water chemistry tests indicate that water quality is not significantly detrimental to fish species presently populating the river. The absence of substantial members of "fish of the year," may be attributed to two probable causes. These causes are: 1) silt deposition on eggs which resulted in their being smothered and 2) fluctuating water levels leaving eggs exposed during various manipulations of water levels. It should be obvious that either together or separately, the stated conditions would be fatal -- hence, poor year class strength for many species, especially for those species relegated to nesting and spawning in the shallow areas.

Many fish utilize benthic and planktonic organisms as food. Data were not available to determine the effect of siltation upon these organisms at this time.

Recommendation

Additional information is needed on both Connecticut River erosion patterns and the subsequent effects upon the biological resources. Power is needed. So are the nation's biological resources. Therefore, it is suggested that an initial examination and a continuous monitoring program be established. It is necessary to continue power generation to determine its effects upon erosion and silt deposition patterns. Adjustments may be able to be made in the mode of operation, which in turn will minimize negative environmental effects.

Bibliography

Connecticut River Basin Coordinating Committee. 1970 Fish and Wildlife Resources, Appendix G, Volume V, Comprehensive Water and Related Land Resources Investigation - Connecticut River Basin.

Morrison, George. 1968, Resident Fish Population Studies (February 15, 1967 - March 31, 1968). New Hampshire Fish and Game Department.

Morrison, George. 1970, Resident Fish Population Study. (July 1, 1969 - June 30, 1970). New Hampshire Fish and Game Department.

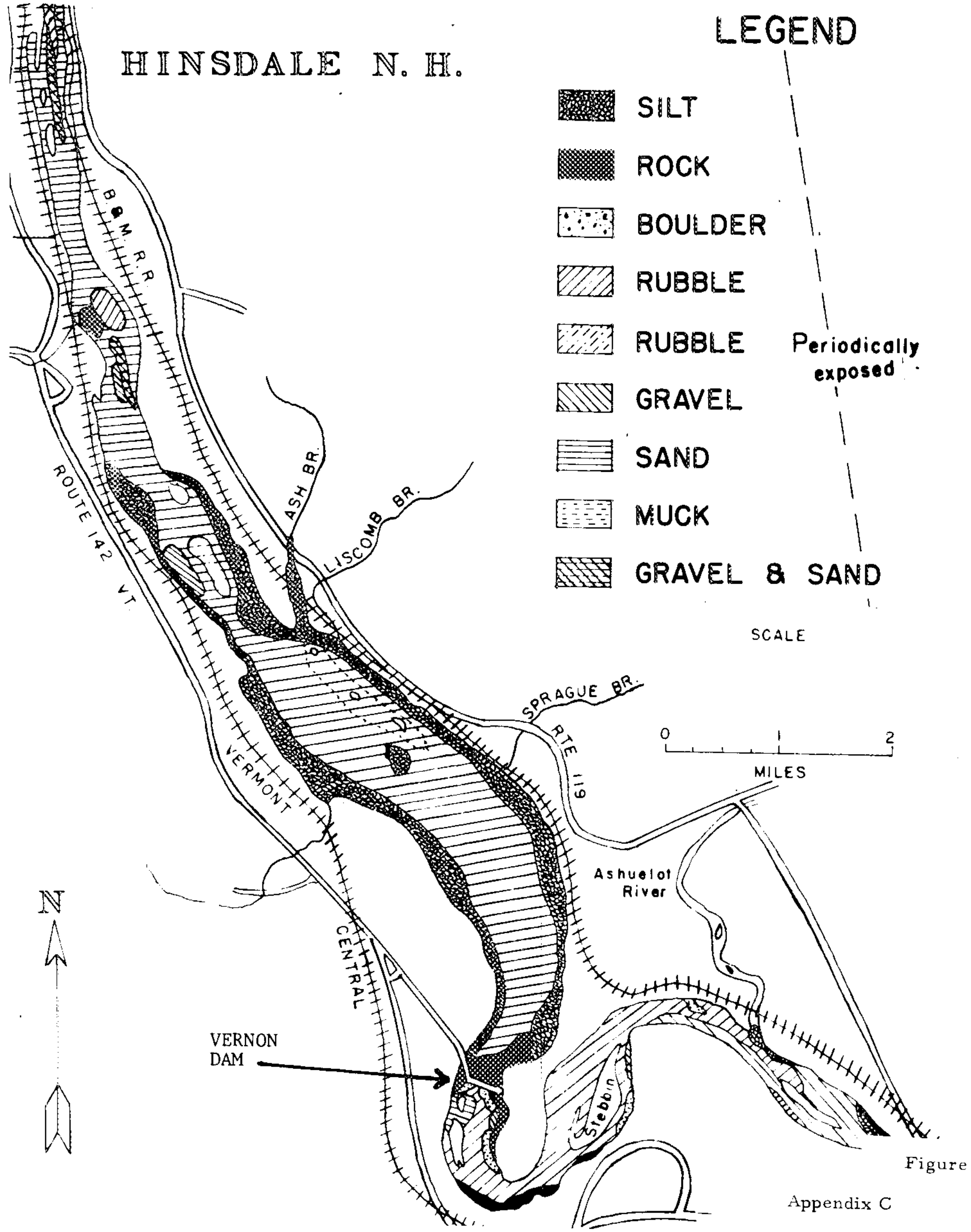


Figure 1

Appendix C

TECHNICAL REPORT ON THE SEDIMENTATION PROBLEM OCCURRING AROUND THE HYDRO-ELECTRIC POOLS

Environmental Protection Agency

Our files contain no sedimentation information, but according to a map shown to me by the Bureau of Sport Fisheries and Wildlife, there seems to be a bank sloughing and sedimentation problem occurring behind the hydro-electric dams. The evidence shown on the map indicates that the sediment deposits are primarily from drawdown induced slides and groundwater seepage induced slides. The sediments do not appear to be localized around the mouths of any entering streams. However, the sloughing or slumping could be enhanced by local gullying induced by runoff from urban areas. The gullys can cause a weakening of the river bank, thus making it more susceptible to other erosion pressures.

The map indicated that the sediment deposits were accumulating to a large extent near shore. This is probably due to the decreased current scouring action in the impoundment. The principle time these sediments would be removed would be during the infrequent periods of ice scour or flooding.

The effects these sediments will have on the impoundment are determined to a large extent on the depth of their deposition. If the deposition occurs below the depth of effective light penetration, the main effect will be the leaching of materials from the newly exposed unstable sediments. However, the water moves out of the reservoir too rapidly to cause any taste and odor problems or ionic buildup which could lead to staining. If the deposition occurs within the depth of effective light penetration, the sunlight could induce plant growth and algal growths or scums along the shores. Whether these would be moved out during flow releases would depend upon the subsequently induced current. This plant growth and possible algal mats would induce only aesthetically displeasing effects because of the limited detention time of the impounded water. The aspect of raw streambanks with trees toppling, or about to topple, into the stream are also aesthetically displeasing. These aesthetic considerations may be important where recreational activity is important.

If excessive erosion and sediment transport are induced by the pool fluctuation, then the problem becomes more severe. Any excessive suspended or transported sediment can cause gill scour, spawning bed destruction, or benthic organism smothering, if severe enough.

Based upon the limited information available, these situations are speculative at this point. However, the situation does seem severe enough to warrant further investigation.

MECHANICS OF STREAMBANK EROSION

CONNECTICUT RIVER, NEW HAMPSHIRE AND VERMONT

New England Division - Corps of Engineers

28 February 1974

1. Introduction. The following is a brief discussion of the mechanics of streambank erosion along the Connecticut River between the Vernon Dam and the head of the impoundment for the Wilder Dam. The processes of streambank erosion are described and ranked in order of importance. Changes in patterns of streambank erosion attributable to the impoundments for the Vernon, Bellows Falls and Wilder Dams are assessed to the extent allowed by the limited information available.

2. Soils. In the reach under discussion, the Connecticut River flows through areas of variable soil types. For present purposes, these are grouped in three categories: course-grain soils, such as gravel and sandy gravel, exhibiting moderately high resistance to erosion; glacial till soils of variable but generally high resistance to erosion; and fine-grain soils, such as sandy silt and silty fine sand, which are highly erodable. As might be expected, most of the reported streambank erosion problems have occurred in soils of the last group.

3. General. Streambank erosion may be defined as the removal of material from the bank by processes attributable to the action of moving water. The extent and rate of streambank erosion are governed by such factors as climate, topography, soil conditions and conditions imposed by man. Many of these controlling factors vary with time and the overall pattern of streambank erosion is one of constant change. Typical of this situation are such phenomena as the major change in a river course during a flood, the cumulative minor changes in river course constantly taking place in meandering reaches and the transient episodes of bank erosion occurring on a seasonal, or even daily, basis.

4. Processes of Streambank Erosion. The processes by which streambanks are eroded are most often interrelated and frequently concurrent. The predominant process is the removal of bank material by the tractive force of flowing water. From the standpoint of the volume of

material affected, continuity of action and overall effects, this is the predominant process. The removal of bank material by wave action is a significant bank erosion process in reaches of slow flow, as in impounded reservoirs. Ice action is a process of localized importance. Bank slides, while of relatively minor significance with respect to overall effects, often have great local impact.

5. Tractive Erosion.

a. The tractive forces exerted by flowing water upon a streambank tend to move soil particles into the current where they are carried downstream and eventually deposited. The speed of this process is governed principally by the direction and velocity of the current, the nature of the bank material and the slope of the bank. Fine-grain soils can be affected by current velocities as low as 2 feet per second.

b. Patterns of tractive streambank erosion change even if the total flow of the stream is constant. The current velocity at a particular point on the bank is partially a function of the cross-section area of the channel and the general direction of flow. As the bank is eroded, the channel area is increased with a resulting decrease in velocity and rate of tractive erosion. The eroded bank material, however, is deposited in the channel further downstream where it reduces the channel area with a resulting increase in velocity and rate of tractive erosion. It is not unusual, therefore, to find particular reaches of a streambank going through cycles of rapid tractive erosion, apparent stability and shoaling over extended periods.

6. Wave Action. Waves striking a shoreline of soil move the soil particles towards the formation of a stable beach profile. The extent and rate of the resulting erosion is governed chiefly by the height of the waves, the character of the soil and the original slope of the shoreline. Wave action erosion, in the area under study, is of potential significance in the impounded reaches where substantially high waves can be generated by the wind or the operation of power boats. It is not known, at present, whether this erosive process of itself has acted to a noticeable extent in the three impounded reaches although the possibility has been recognized by several agencies.

7. Ice Action. Ice in a stream can move bank material by the grinding and gouging action of blocks drifting with the current and by a plucking action as ice formed along the bank is torn loose. While the actual volume of bank material moved by ice action is usually small, the

affected banks are rendered more susceptible to erosion by other processes. Streambank erosion through ice action appears to be a problem only where it has an impact on human activities. Elsewhere, it is only a minor component of the spectrum of erosive processes.

8. Slides.

a. Streambank slides involve the sudden movement of soil masses into the stream. The volume of the sliding mass may range from a few cubic feet to thousands of cubic yards. It is unlikely, however, that a slide involving more than a few hundred cubic yards has occurred or will occur in the area of study. Each slide is essentially an adjustment of the bank to a more stable condition. Sliding at a given location, therefore, does not recur until an unstable condition is reinstated.

b. Streambank slides fall into three categories on the basis of causes. The most common type is that resulting from changes in the bank slope caused by tractive erosion, wave action or ice action. The term "undercutting" is often used in this connection, although the slope change causing a slide may not be as extreme as the term indicates. Slides of this type can be of any magnitude but most are small and frequently recurrent where other erosive processes are active.

c. Another type of slide is that caused by changes in internal stresses in the bank resulting from changes in stream level. Although often referred to as "drawdown" slides, they can occur with a rising as well as a falling stream level. The frequency of recurrence of this type of slide is low as long as no great change takes place in the range of stream level fluctuations. This is exemplified by the common experience with new impoundments where "drawdown" slides are numerous during the first year or two and then become very rare. It is possible, however, for tractive erosion or wave action to eventually steepen the banks to a point where a new series of such slides can occur. There is no presently available evidence that this is happening to a significant extent in the reservoirs under study.

d. Changes in the patterns of ground water flow to a stream can cause bank sliding. These changes can be associated with stream level changes or changes in groundwater flows induced by other factors. Slides of this type are usually very small and their effects masked by the results of tractive erosion and wave action. Seepage pressures from ground water flows, however, are very often contributary causes for slides of the "undercutting" and "drawdown" varieties.

9. Impoundment Effects. Impoundment of a stream will affect the pattern of streambank erosion in the impounded reach. In the three reservoirs being considered, it appears that tractive erosion has been reduced, erosion by wave action increased, erosion by ice action unchanged and the incidence of bank slides reduced following a transitory increase during the early years of reservoir operation. It is believed that the net effect of these impoundments has been to reduce the total volume of material moved by bank erosion.

NEDPL-L 20 September 1974

SUBJECT: Implementation of Streambank Erosion Control Evaluation and Demonstration Act of 1974

HQDA (DAEN-CWE-H)
WASH DC 20314

1. Certain areas within the jurisdiction of this office have chronic erosion problems. Many stream reaches, especially in northern and western New England, are attractive from a vacation home development standpoint. Sites on water bodies are particularly attractive, and in view of national commitment to clean up rivers, it can be expected that development pressure and associated erosion problems will be even more critical on New England rivers in the future.

2. The following paragraphs are specific replies, keyed to paragraphs in the subject letter:

8. a. Funding Requirements. Updating the 1969 Corps report, "A Study of Streambank Erosion in the United States," will consist of considerable effort within this office and coordination with other agencies. Attention to streambank erosion and the problems it creates has increased in recent years. Requests for technical assistance on erosion problems by the States and communities indicate that there are many areas that were not considered significant in 1969, but that now warrant some investigation. It is also felt that field investigation should be made in all erosion problem areas to ascertain the nature and extent of erosion, as well as recent development in these areas. An estimated 11 person-months of technical effort will accomplish the updating. This effort, together with associated typing, reproduction, graphic, overhead, etc., is estimated to cost $35,000. A detailed cost breakdown of this updating is presented in Attachment 1.

September 1974
Control
1974

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Mr. Smith/je/511

NEDPL-L 20 September 1974

SUBJECT: Implementation of Streambank Erosion Control Evaluation and Demonstration Act of 1974

8. d. A Point of Contact. Mr. Lawrence Bergen, Chief, Policy and Long Range Planning Branch, has been appointed my Planning Division contact on this matter. Mr. Bergen can be reached at FTS 617-894-2519.

Incl
as

JOHN H. MASON
Colonel, Corps of Engineers
Division Engineer

cc: Mr. Smith
Planning Div Files
Reading File

SMITH

BERGEN

IGNAZIO

BURKE

MASON

ESTIMATE OF COST TO UPDATE REPORT
ON STREAMBANK EROSION
NEW ENGLAND REGION - 1969*

Category			Hours	Rate	Total
Engineer	GS-12	Level	160	9.53	1,525
Engineer	GS-11	Level	800	7.99	6,392
Engineer	GS-9	Level	800	6.63	5,304
Engineer	GS-7	Level	160	5.43	869
Typist	GS-4	Level	120	3.92	470
				Sub-Total	14,560
Cost of Living Raise (1 October 1974, 5.3%)					772
				Sub-Total	15,332
Employee Fringe (30%)					4,600
				Sub-Total	19,932
Planning Division Overhead (22%)					4,385
				Sub-Total	24,317
New England Division Overhead (26%)					6,322
				Sub-Total	30,639
Travel (Per Diem and Auto)					1,500
Drafting and Graphic Arts					1,500
Reproduction of Report					1,000
					34,639
				Round	35,000

* New England portion of "A Study of Streambank Erosion in the United States - 1969"

Attachment 1

For the purposes of this summary section, some of the more noteworthy examples of streambank erosion determined by this study in terms of land loss and damages are as follows:

(1) Housatonic River (Washington Mountain Brook) at Lee, Massachusetts. Fifteen areas of slides along brook, banks of which are fifty to eighty feet high. Sedimentation at confluence obstructs the town's water supply intake which must be cleaned out every three to five years. Much damage to bridges, highways, retaining walls, abutments, present riprap and farmland.

(2) Housatonic River in vicinity of Sheffield, Massachusetts. Three miles of caving banks along the river which meanders through farmland between Great Barrington and Sheffield, Massachusetts.

(3) Housatonic River below Lee, Massachusetts. Bank erosion of farmland and land suitable for industrial development between Route 102 Bridge and Hurlbut Dam.

(4) St. John River (Fish River) at Fort Kent, Maine. Meanders eroding toe of twenty foot banks which then slough into river.

(5) Connecticut River (Fort River) at Hadley, Massachusetts. Fort River has cut new channel to Connecticut River which is migrating easterly at the rate of one-quarter mile in twenty-five years. Sixty acres loss in twelve years. Town sewage treatment plant is threatened and sedimentation being deposited downstream.

(6) Connecticut River at Hadley-Hatfield, Massachusetts. River meanders cutting banks and threatening dikes. Significant loss of land.

(7) Connecticut River at Charlestown, New Hampshire. Eroding bank at rate of ten feet per year will threaten town sewage disposal facility.

(8) Connecticut River at Windsor, Connecticut. Two-thousand feet of bank eroding at the rate of five feet per year. Loss of tobacco land.

Attachment 2

(9) Cocheco River at Gonic, New Hampshire. Landslide due to erosion on five-hundred foot length of bank twenty to forty feet high at center of town. Bank receded ten feet in five years. Seven properties affected and further threatened.

(10) Saco River at North Conway, New Hampshire. Building property loss and cemetery threatened. High sediment deposition forces river against twenty foot high erodeable banks.

Environmental

An important consideration in the problem of streambank erosion is the visual effects of such action. Information from FWPCA is that \$1.2 billion will be spent in New England in the next decade to construct secondary sewage treatment facilities including intercepter lines. Federal funds will account for 50 to 55% of the expenditure. O and M costs are forecast to run \$40 million annually. If these amounts are to be spent to clean up the streams, a closer look needs to be taken of the effects of bank erosion on turbidity, discoloration of the streams, and sedimentation pollution the detriment of the sports fishery. Another unsightly aspect is that of raw streambanks with trees toppling or about to topple into the stream. These considerations are especially important in a region where a thriving recreational tourism trade provides an annual expenditure in excess of \$1.5 billion.

7. AUTHORITY AND RECOMMENDATIONS

General

Corps' authorities for participation in streambank erosion mitigation are generally limited to problems coming within the purview of Sections 13 and 14 of P.L. 79-526, the 1946 Flood Control Act. Some limited participation is also available under P.L. 99 when public welfare is a consideration. It is also to be noted that paragraph 124-C of EM 1120-2-101 and other authorities require consideration of provisions for prevention of damages to others from project operation such as from erosion of banks.

Report On
Inventory of Streambank Erosion
Saco River

Introduction

This report presents the results of an effort to inventory sites of streambank erosion on the Saco River in Carroll County.

The objective of the inventory was to get some statistical data on the extent and scope of bank erosion on the Saco.

The procedure used was to make a stereo study of aerial photos of the river to identify possible erosion sites. These were then checked in the field by boating down the river and making estimations of dimensions and other data thought to be pertinent.

We identified 57 sites. The total length of these eroding banks was 41,860 feet or 7.9 miles. The height of the banks varied from 5 to 100 feet. The total area of eroding slope amounted to about 17 acres.

Some Statistics on 57 sites

1. Length (l)

Total = 41,860 feet
= 7.9 miles
Average = 734 feet

Range:	Less than 500 feet	= 27 sites
	500 to less than 1,000 feet	= 9
	1,000 feet to less than 1,500 feet	= 13
	1,500 feet to less than 2,000 feet	= 4
	2,000 feet and over	= 4
		57

Shortest - 100 feet
Longest -2,100 feet

2. Height (h)

Average - 19 feet

Range:	5 feet to less than 10 feet	= 8 sites
	10 feet to less than 20 feet	= 40
	20 feet to less than 30 feet	= 3
	30 feet, up to 100 feet	= 6
		57

Lowest - 6 feet
Highest -100 feet

attachment 3

3. Area of Slope

Total	=	744,700 square feet	
	=	17 acres	
Smallest	=	500 square feet	
Largest	=	90,000 square feet, 2.1 acres	
Average	=	13,000 square feet	
Average	=	.3 acre	
Range:		Less than 5,000 square feet	= 24 sites
		5,000 to less than 10,000 sq.feet	= 8
		10,000 to less than 15,000 sq.feet	= 6
		15,000 to less than 25,000 sq.feet	= 11
		25,000 to less than 35,000 sq.feet	= 5
		35,000 and over	= 3
			57

4. Bank Slope

Most of the banks are vertical above the water line.

Vertical - 39 sites
Vertical with some overhang - 14 sites
Banks with some outward slope - 21 sites
Thirteen banks had a combination of the above.

5. Textures in the Bank

28 banks showed fines
2 banks showed some till
39 banks showed sands
29 banks showed gravel
11 banks showed cobbles
Most banks showed a mixture.

6. Present Activity

51 of the banks were actively eroding at low water stages
5 banks appeared to erode only during high water stages
3 were inactive and only 5 showed any signs of healing

7. Overfalls and Seeps

Only 4 of the sites showed any overfalls; and 3 showed signs of seeps

8. Causes

Stream flow appeared to be the cause of the erosion in all cases except at one site where people using the streambank were contributing.

9. Abutting Cover

9 banks had a mixture
35 had woodland
12 had brush
18 had grass
1 had none

10. Abutting Land Use

A farming operation could be identified as abutting 22 of the banks.

7 banks were abutted by commercial land uses
16 were abutted by woodlots (as separate from farms)
4 were home sites either vacation or year-round
5 sites were abutted by other types of recreational uses
4 were idle or unknown

11. Damages

Sediment production was of course common to all the sites. No attempt has been made to evaluate this as a damage. Such a study would be beyond the scope of this inventory.

The loss of land is a real damage where the abutting land use is farming. Road, bridge and home damage were factors at some sites.

Walter L. Nelson

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314

Rec'd 28 Jun 74

REPLY TO ATTENTION OF:
DAEN-CWE-H

Hyd Dos. Br
cf: w/Basd. Pres Lacofe
8-202-693-6892
Dooma

SUBJECT: Implementation of Streambank Erosion Control Evaluation and Demonstration Act of 1974

D

Engineering

Division Engineer, New England

1. Reference is made to letter, DAEN-CWP, 21 March 1974, to all Division Engineers, subject, "The Water Resources Development Act of 1974 (PL 93-251)," specifically, paragraph 2h.

2. Section 32 of the Act, entitled "Streambank Erosion Control Evaluation and Demonstration Act of 1974," authorizes a development and demonstration program for streambank erosion control devices. The purpose of this letter is to provide additional guidance for implementing the program.

3. The program, which is authorized for completion on 30 June 1978 at a cost not to exceed $25,000,000, will consist of:

a. An evaluation of the extent of streambank erosion on navigable rivers and their tributaries.

b. Development of new methods and techniques for streambank protection, research on soil stability, and identification of the causes of erosion.

c. Demonstration projects of streambank erosion control, including bank protection works.

d. Submission of a report by the Chief of Engineers to Congress on the results of the program and containing recommendations on means for the prevention and correction of streambank erosion.

4. The work under 3a will involve an updating of the Corps 1969 report "A Study of Streambank Erosion in the United States." We expect to conduct the update in coordination with SCS and other Federal agencies under the same procedures as in 1969. This will require review of the data gathered

previously for accuracy and surveys of new locations of streambank erosion. Coordination with Federal agencies will be initiated by OCE and further instructions will follow. The update will be scheduled for accomplishment in FY 1975 and 1976.

5. The Waterways Experiment Station will make a literature search and conduct such research as will be required to accomplish the work under 3b. The Station also will be assigned responsibility for monitoring instrumentation, data collection and analysis of results for demonstration projects.

6. To the extent that funds will permit, demonstration projects will be constructed in various locations, in addition to those sites authorized by the Act on the Ohio, Missouri and Yazoo rivers. The additional sites will be selected to reflect the following:

a. A variety of geographical conditions.

b. Streams with naturally occurring erosion problems caused by excessive flow velocities and/or wave action.

c. Streams with erosion problems caused or increased by man-made structures or activities such as vessel movements which create excessive waves in inland waterways.

d. Sites to be located where streamflow and other conditions will assure successful demonstration of the effectiveness of selected types of bank protection by the end of the program period, 30 June 1978.

e. Sites to be located in areas where non-Federal interests desire the construction of bank protection works.

f. Non-Federal interests ~~shall agree to~~ provide, without cost to the United States, lands, easements and rights-of-way necessary for construction and subsequent operation of the projects; hold and save the United States free from damages due to construction, operation and maintenance of the demonstration projects; and operate and maintain the projects upon completion.

7. District Engineers in whose Districts demonstration projects will be constructed will have responsibility for design, construction and collection of data for the demonstration projects. However, the plan for data collection aspects is to be coordinated with the Waterways Experiment Station.

DAEN-CWE-H
SUBJECT: Implementation of Shoreline Erosion Control Demonstration Act of 1974

8. In order to expedite development of a funding schedule for the field surveys of streambank erosion areas and to facilitate selection of demonstration project sites, you are requested to provide the following information, ATTN: DAEN-CWE-H, by 15 September 1974:

a. Funding requirements for FY 1975 and 1976 to accomplish the field surveys described in paragraph 4.

b. Potential sites for demonstration projects which will meet the general criteria outlined in paragraph 6, accompanied with a brief description of the physical characteristics of each site and a statement justifying its selection.

c. A listing of possible control devices (including vegetative) that may be developed or demonstrated at potential sites.

d. A point of contact in your Division and appropriate Districts for additional technical details as may be required.

9. It is emphasized that the above information is preliminary for use in formulation of procedures for complying with the provisions of the Act and for selecting demonstration project sites in locations not specified in the Act. No commitments should be made to any group or local entity on site selections, or on control devices which may be demonstrated.

10. Until funds are appropriated and allocated to this program, firm schedules of accomplishment of work under the Act and development of demonstration projects can not be made. Additional guidance will be issued after the requested information is received and funds are allocated to the program.

FOR THE CHIEF OF ENGINEERS:

J. W. Morris

J. W. MORRIS
Major General, USA
Director of Civil Works

Mr. Swain

NEDPL-L (16 July 1974) 1st Ind
SUBJECT: Connecticut River Streambank Erosion, Wilder Lake, New Hampshire and Vermont to Turners Falls Dam, Massachusetts - 12140

DA, New England Division, CE, Waltham, Massachusetts 7 August 1974

TO: HQDA (DAEN-CWP-A) WASH DC 20314

1. Description of the Study Area - The study area is that portion of the main stem of the Connecticut River from the head of the Wilder Power Reservoir below Woodsville, New Hampshire, to a point on the main stem of the river in Massachusetts just below the Turners Falls Power Dam. The Turners Falls project is owned by the Western Massachusetts Electric Company, and the other three projects are owned by the New England Power Company. These are the only power projects in the 140 mile reach of the Connecticut River between Turners Falls, Massachusetts and Woodsville, New Hampshire.

a. The Wilder Dam is located on the Connecticut River at river mile 217. The drainage area at the site is 3,375 square miles. The dam is across the main stem of the Connecticut in the towns of Hartford, Vermont and Lebanon, New Hampshire, and the reservoir extends up the Connecticut River Valley in New Hampshire and Vermont. The reservoir is about 45 miles long with about 105 miles of shoreline with a surface area of 3,100 acres and a total volume of about 35,000 acre-feet at full pond elevation of 385 feet msl. Backwater effects raise the reservoir water surface elevation to about elevation 400 msl at the upstream end of the reservoir. The usable pondage is 13,350 acre-feet with 5 feet of drawdown. The Wilder project is operated in coordination with the other generating plants of the New England Power Company. It is operated as a peaking plant during low flow periods and as a base-load plant during high flow periods.

b. The Bellows Falls Dam is located on the Connecticut River at river mile 174; the drainage area at the site is 5,415 square miles. The dam is located in the towns of Rockingham, Vermont and Walpole, New Hampshire and the reservoir extends about 25 miles upstream with about 72 miles of shoreline. It has a surface area of 2,800 acres and a total volume of 30,000 acre-feet at full pond elevation, 291 feet msl. The backwater effects raise the reservoir water surface elevation to about elevation 298 msl at the upstream end of the reservoir. The usable pondage is 9,600 acre-feet with 4 feet of drawdown. The project is operated as part of the company's interconnected system and operates as a peaking plant in low flow periods and as a baseload plant during high flow periods.

c. The Vernon Dam is located on the Connecticut River at river mile 141.9. The drainage area at the site is 6,266 square miles. The dam is located in the towns of Vernon, Vermont and Hinsdale, New Hampshire and the reservoir extends up the Connecticut River Valley 27.7 miles with about 69 miles of shoreline. It has a surface area of about 2,550 acres and a total volume of about 40,000 acre-feet, at full pond elevation, 220 msl. Backwater effects raise the reservoir water level to about elevation 227 at the upstream end of the reservoir. The usable pondage is 11,950 acre-feet with 5 feet of drawdown. The Vernon project is part of the company's interconnected system of hydro and thermal developments and is operated to supply baseload during the spring run-off, peaking power during low flow summer months and a combination of both modes of operation during the intermediate river flows during the late fall and winter.

d. Turners Falls Dam is located on the Connecticut River at river mile 122 where the drainage area is about 7,140 square miles. The dam is located in the towns of Montague and Gill, Massachusetts and the reservoir extends up the Connecticut River Valley about 20 miles with about 50 miles of shoreline. It has a surface area of 2,800 acres and a total volume of about 28,000 acre-feet at full pond elevation, 180 msl. Backwater effects raise the reservoir water level to about elevation 186 msl at the upstream end of the reservoir when the flow is about 9,000 cfs. The usable pondage is about 8,650 acre-feet. The project is owned by Western Massachusetts Electric Company which does not own any upstream storage facilities, but does use the storage facilities of the New England Power Company. Drawdown of the reservoir is normally limited to 3.25 feet so as to provide optimum recreational environment.

2. Desires of Local Interests - Local interests desire management of the main stem of the Connecticut River so as to reflect a concern for its total environment. Citizens are concerned at the degree of bank erosion which is taking place, and maintain that the rate of erosion is accelerated when the level of the power pools fluctuates. Local interests of New Hampshire and Vermont, as well as environmental groups, desire that improvements be made so as to reduce or eliminate the soil erosion problem. These interests also desire that the water level in the lakes in question be maintained at a fairly uniform elevation because of the erosion problems. This would require significant changes in operating procedures of the hydroelectric generating plants, and consequent losses of power capacity and generation.

3. Existing Studies - There are no outstanding reports of existing authorities to study any areas of similar interest along this reach of the Connecticut River within which this study could be combined. Because of the comprehensive

nature of the problem and the detailed scope of the required investigation, the study would be beyond the scope of Section 14 (Emergency Bank Protection) or the on-going Connecticut River Basin Supplemental Study. There have been numerous requests, over the years, for Corps assistance with bank erosion problems in the study area, at various locations. Because of the chronic nature of erosion problems in the study area, and the fact that the over-all magnitude is beyond the scope of the Section 14 Authority, a survey scope study appears warranted.

4. Completed Studies - A reconnaissance report has recently been completed on a portion of the subject study area. The Report on Connecticut River Basin Bank Erosion Study, a two-month effort, compiled available bank erosion literature on the three hydroelectric projects on the Connecticut River in New Hampshire and Vermont. The three projects included in the report are the reservoirs of Vernon, Bellows Falls and Wilder. The report states that available literature and data reveal that 51.0 of the 242.0 miles, or 21.1 percent of river bank investigated show erosion; and it is estimated that the annual loss of bank for Sullivan County, New Hampshire and Windsor and Orange Counties in Vermont, is 19.6 acres of land or 215,000 cubic yards. Proportioning this to the length of shoreline in reservoirs of the three dams, it appears that approximately 32 acres or 355,000 cubic yards are being lost annually. This figure of land lost to erosion represents the gross values of area and volume actually removed from the banks. No effort was made to evaluate the amount of shoaling which is taking place at the same time. It is quite possible that the amount of new land being formed by deposition will equal the amount being lost. Since Turners Falls Reservoir represents an additional 50 miles of river bank, the estimated annual loss of land for the entire study area would exceed 400,000 cubic yards.

Under Section 14 (1946 Flood Control Act, as amended), NED determined that a bank erosion protection project (consisting of revetments) at Charlestown, New Hampshire had economic justification. This project was advertised for construction during July 1974.

5. Causes of Erosion - The conditions which are creating the erosion problems, i. e., land development, weathering, ice effects, wave action, river velocities, raising and lowering of lake levels, sedimentation conditions, types of soils, frost effects, vegetation cover, and root patterns, are typical

to many of our region's streams. Many theories have been developed on remedying bank erosion brought on by the above conditions, but none has been accompanied by the factual data necessary to arrive at a comprehensive solution.

6. <u>Benefits of Study</u> - The study, welcomed by environmental groups, would recommend ways to decrease the estimated 400,000 cubic yards of land lost annually. In terms of water quality and fishery resources, a study on erosion elimination could result in reducing the sedimentation along the banks of the main stem, leading to a cleaner river bed, and conceivably larger fish populations, as food sources become more abundant. Fish populations would also increase with a decrease in the smothering of fish eggs by deposited sediment. It could also lessen the degree of water treatment needed by downstream users of the stream. This type of study would also be of major interest to the recreation industry in terms of maintaining an aesthetically pleasing shoreline. Since the study would provide bank stabilization information, the risk involved in developing the river banks would be minimized, thus benefiting the communities along the river.

7. The estimated cost of a bank erosion study is indicated on the attached PB-6. It is estimated that the study could be completed in 30 months.

8. A map showing the study area is inclosed.

FOR THE DIVISION ENGINEER:

4 Incls
1&2 wd
~~Incl~~ 3, as
~~as~~ 4 as

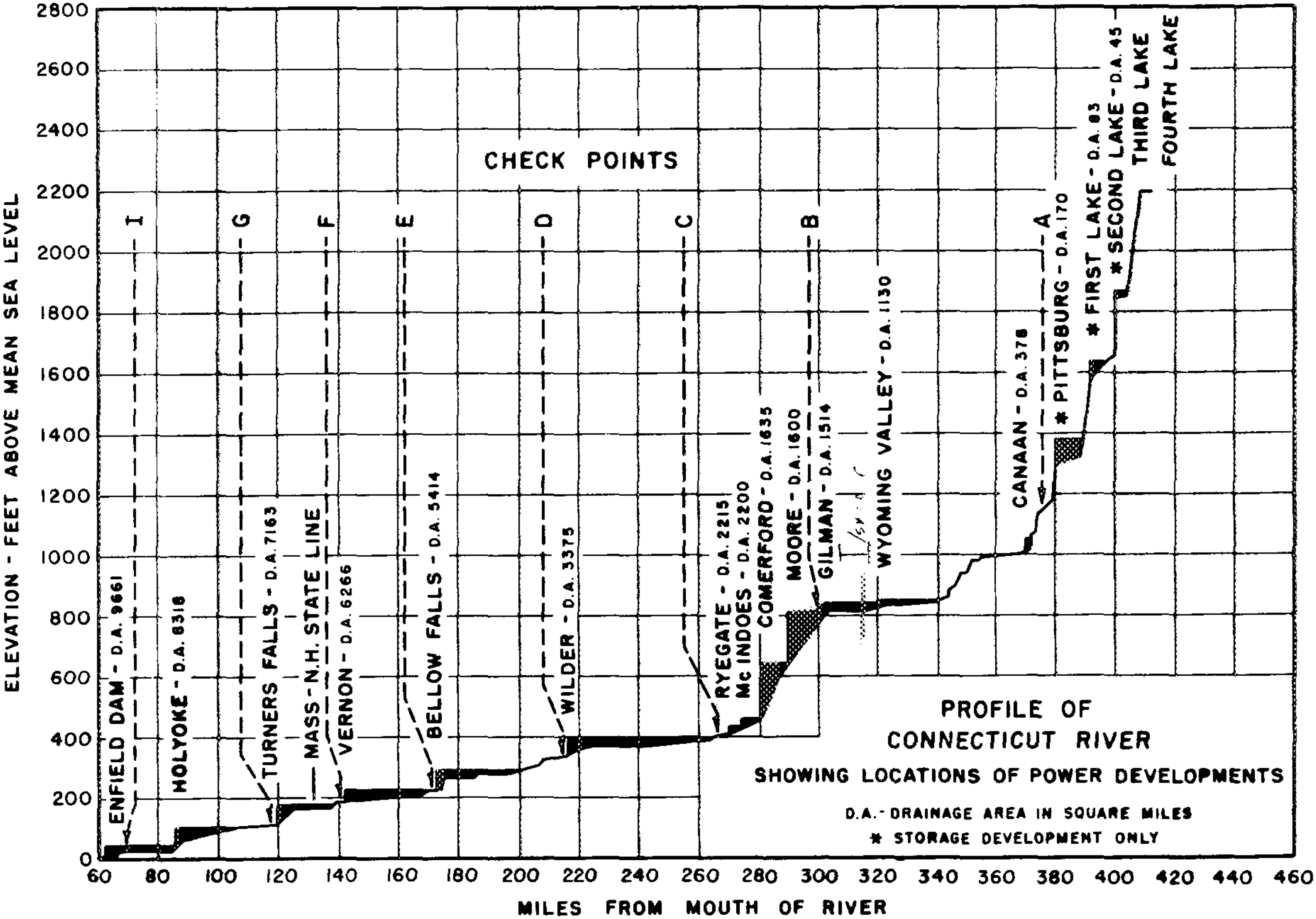
JOSEPH L. IGNAZIO
Chief, Planning Division

HUNT

BERGER

IGNAZIO

cc: Mr. Ignazio
Prog. Dev.
Mr. Swaine
Mr. Smith
Pl. Div. File



SUB COMMITTEE ON STREAM REGULATION

APRIL 1967